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VOLUME 56 NUMBER 4

# ARCHIVES OF SURGERY

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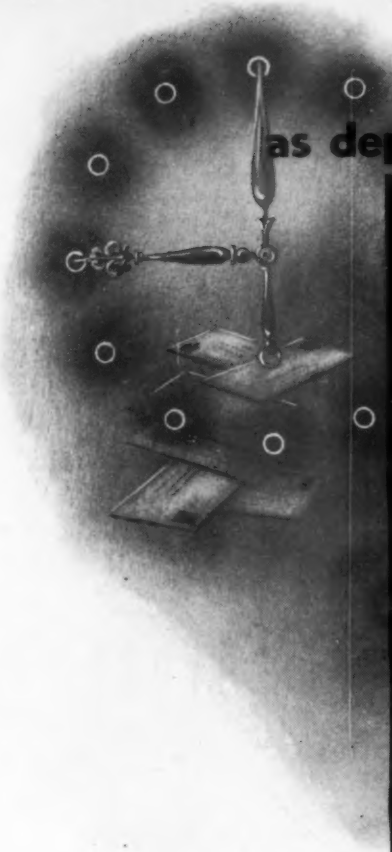

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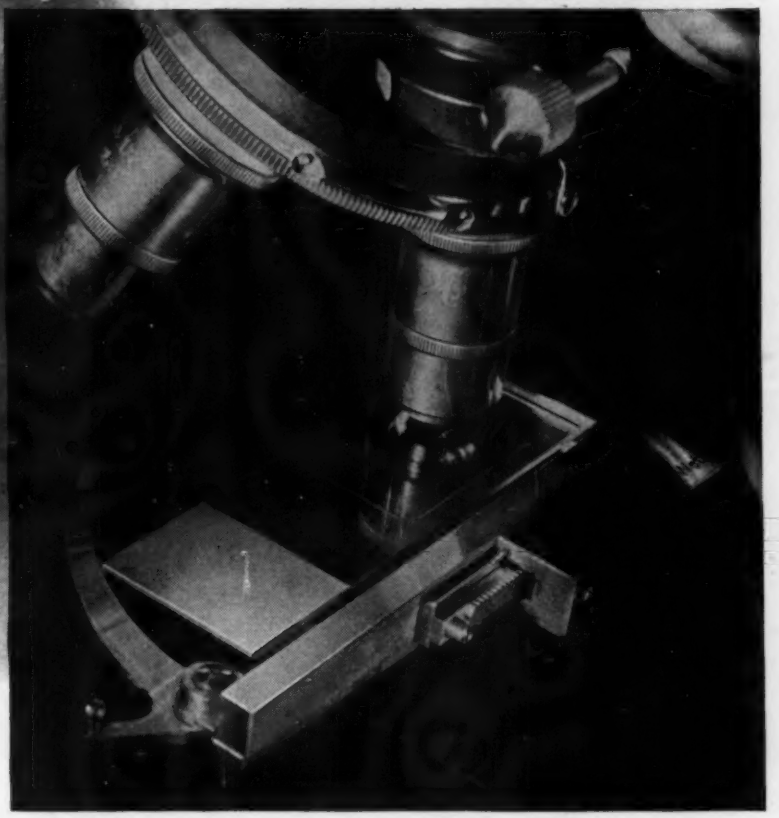

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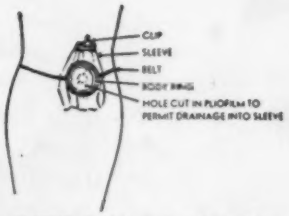


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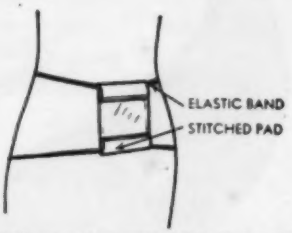


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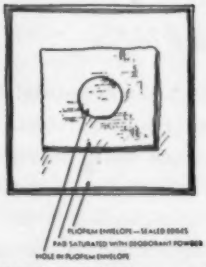

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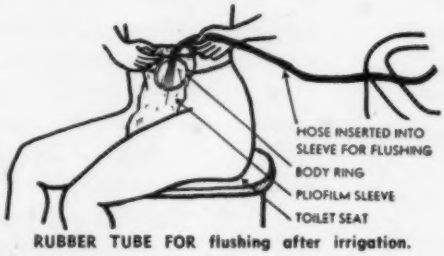


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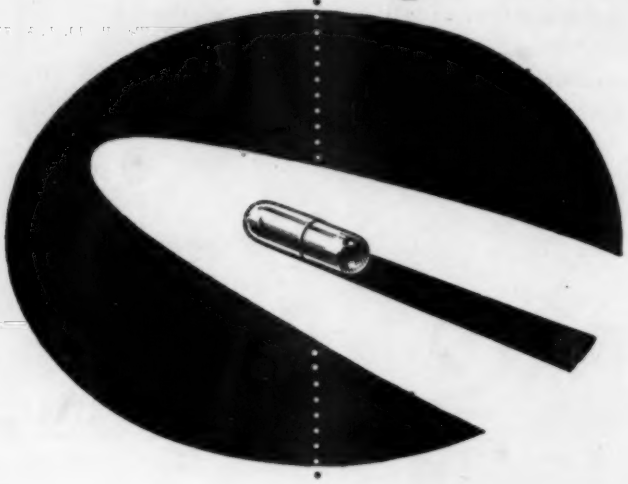

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# USE OF THE DEFUNCTIONALIZED LOOP OF JEJUNUM IN BILIARY AND PANCREATIC SURGERY

L. W. PETERSON, M.D.
AND
WARREN H. COLE, M.D.
CHICAGO

ON VARIOUS occasions it becomes necessary to perform anastomoses between the intestinal tract and the gallbladder, common duct, cysts of the common duct, pancreatic cysts and pancreatic fistulas. Direct anastomosis to the side of the duodenum or jejunum represents a simple type of procedure to allow discharge of the bile or pancreatic secretion into the intestine. Such a direct anastomosis would naturally allow reflux of food and intestinal content, at least to a mild degree, into the structure anastomosed with the intestine. It would appear that this reflux of food and irritating intestinal content might give rise to infection. In the majority of instances this does not occur, at least not to a detrimental degree, particularly when an operation such as cholecystoduodenostomy is performed as a palliative procedure for inoperable carcinoma of the head of the pancreas.

To minimize the danger of infection, an anastomosis between the gallbladder and the jejunum, with an opening between the two loops of jejunum 20 to 30 cm. from the anastomotic site, has been suggested (Enderlen[1], 1923). Although this enteroanastomosis should theoretically prevent passage of food around the jejunal loop, there is ample proof, as revealed by barium studies, that it does not (fig. 1). Although the regurgitation usually does not give rise to demonstrable infection, as previously intimated, we have ample evidence, presented in the protocols of cases 1 and 2, that severe infection can develop. The anastomosis in each of these cases was performed between a loop of jejunum and the hepatic duct at the hilus of the liver as shown in figure 2*A*. In the majority of instances, infection resulting from such anastomoses develops because of stricture formation at the

From the Department of Surgery, University of Illinois College of Medicine.

Read at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

1. Enderlen, cited by Eliot, E., Jr.: Benign Cicatrical Strictures of the Bile Ducts, Tr. Am. S. A. **54**:195-228, 1936.

anastomotic site. However, from the evidence presented in the two protocols mentioned, it is obvious that the infection (suppurative cholangitis) was secondary to reflux alone, because all signs of infection disappeared promptly and completely after the proximal loop of jejunum was interrupted. At this secondary operation (fig. *2B*) nothing was done to the anastomosis between the hilar duct and the jejunum because it was patent, with the "vitallium" tube still in place.

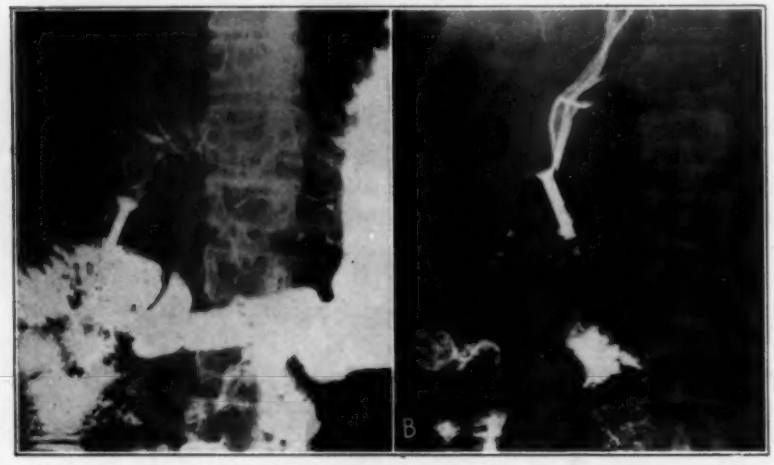


FIG. 1.—*A*, roentgenogram made after a barium meal shows regurgitation of barium into the intrahepatic bile ducts after operation (fig. *2A*) in which the stump of the common duct had been anastomosed to a loop of jejunum (without folds or valves in the proximal arm) in a patient with a stricture of the common duct. At the time this was taken, the patient was having numerous attacks of chills and fever, for which the proximal arm was severed as shown in figure *2B*. After this operation the chills and fever disappeared; a roentgenogram after a barium meal then revealed no regurgitation. (After Cole, Ireneus and Reynolds, Ann. Surg. **122**:490 1945.) *B*, roentgenogram made after a barium meal on a patient having the same condition and undergoing the same operation as the patient represented in *A*. This patient likewise was having chills and fever secondary to regurgitation into the intrahepatic ducts, but these disappeared as did also the regurgitation after severance of the proximal arm as shown in figure *2B*.

The Roux Y principle as originally used by Monprofit[2] in 1904 and by Whipple[3] in 1938 when performing a cholecystenterostomy has more recently been utilized[4] for anastomosis of the common duct to the jejunum. If this arm of jejunum is more than 20 to 30 cm.

2. Monprofit, A.: Une nouvelle methode de cholecystenterostomie: La cholecystenterostomie en Y, Arch. prov. de chir. **13**:380-383 and 449-453, 1904.

3. Whipple, A. O.: Surgical Treatment of Carcinoma of the Ampullary Region and Head of Pancreas, Am. J. Surg. **40**:260-263, 1938.

4. Allen, A. W.: Method of Re-Establishing Continuity Between the Bile Ducts and the Gastro-Intestinal Tract, Ann. Surg. **121**:412-424, 1945. Cole, W. H.; Ireneus, C., and Reynolds, J. T.: The Use of Vitallium Tubes in Strictures and Absence of the Common Bile Duct, ibid. **122**:490-521, 1945.

long, we are convinced that regurgitation will not occur into the liver. At any rate, we have not found any evidence in roentgenograms made after a barium enema that regurgitation has occurred. Since the regurgitation would have to take place against the peristaltic current, its occurrence would appear unlikely. When the bile duct is anas-

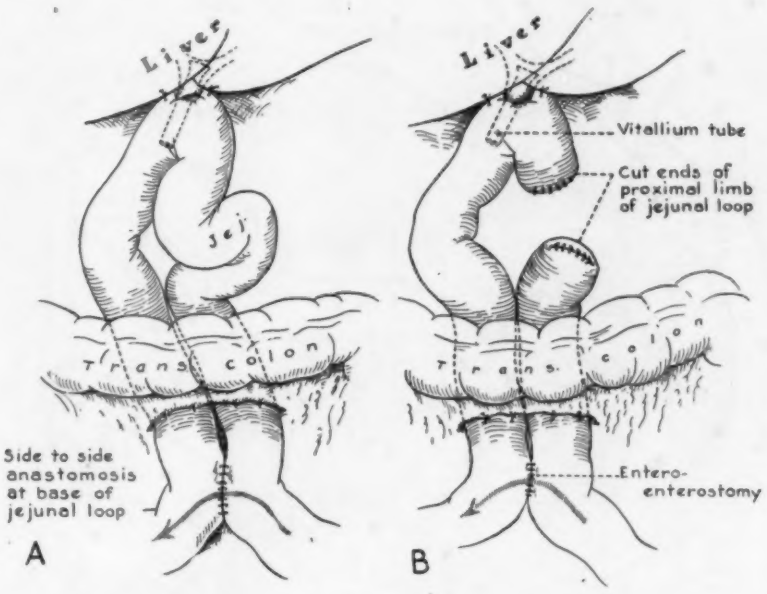


FIG. 2—*A*, in 5 of our early cases of stricture of the common duct we anastomosed the stump of the duct to a loop of jejunum as illustrated. One of the patients died a few days after operation. Within a few weeks after operation on the remaining 4 chills and fever developed; these symptoms promptly abated after severance of the proximal arm in 2 patients as shown in *B*. The fourth patient died of abscesses of the liver. The fifth had attacks of chills and fever for two years but refused further operation. These symptoms finally disappeared, and for the past two years she has been asymptomatic. Roentgenograms now reveal absence of the "vitallium" tube and no reflux of barium, indicating that the opening between the common duct and the intestine has stenosed sufficiently to prevent regurgitation but not to produce symptoms. *B*, severance of the proximal limb.

tomosed to the side of the intestine or to the end of a loop of intestine, regurgitation becomes much more possible.

Although we are convinced that regurgitation of intestinal content into the hepatic duct is capable of producing an infection of the suppurative cholangitis type, we have nevertheless not encountered it when at least 2 or 3 cm. of common hepatic duct was available for anastomosis with the side of the intestine. It appears that the dilated stump of hepatic duct may act as a reservoir and protect the ducts within the liver from the infection. We have seen suppurative cholan-

gitis develop on two occasions when a sizable stump of hepatic duct remained for anastomosis or transplantation into the intestine, but in

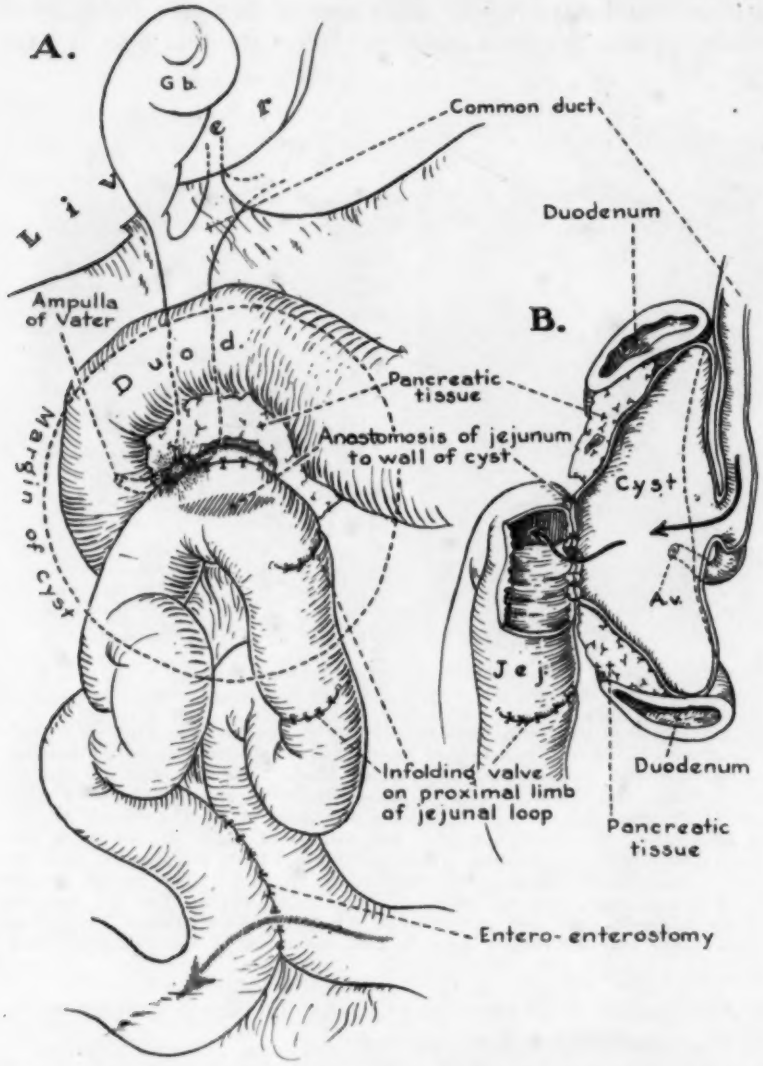


FIG. 3.—In case 3 a cyst of the distal end of the common duct presented anteriorly, flattening out the head of the pancreas. It could not be marsupialized, so it was anastomosed to a defunctionalized loop of jejunum after splitting of the pancreas to obtain exposure of the cyst. Two folds or valves were created in the proximal arm. The severe pain which was present before operation completely disappeared, and the patient has been asymptomatic ever since.

each instance a stricture was found to be present and obviously was the direct cause of the chills and fever.

When a cyst of the common duct is anastomosed to the side of the duodenum or jejunum, it is possible or probable that suppurative cholangitis will not develop, perhaps because the cyst intervenes be-

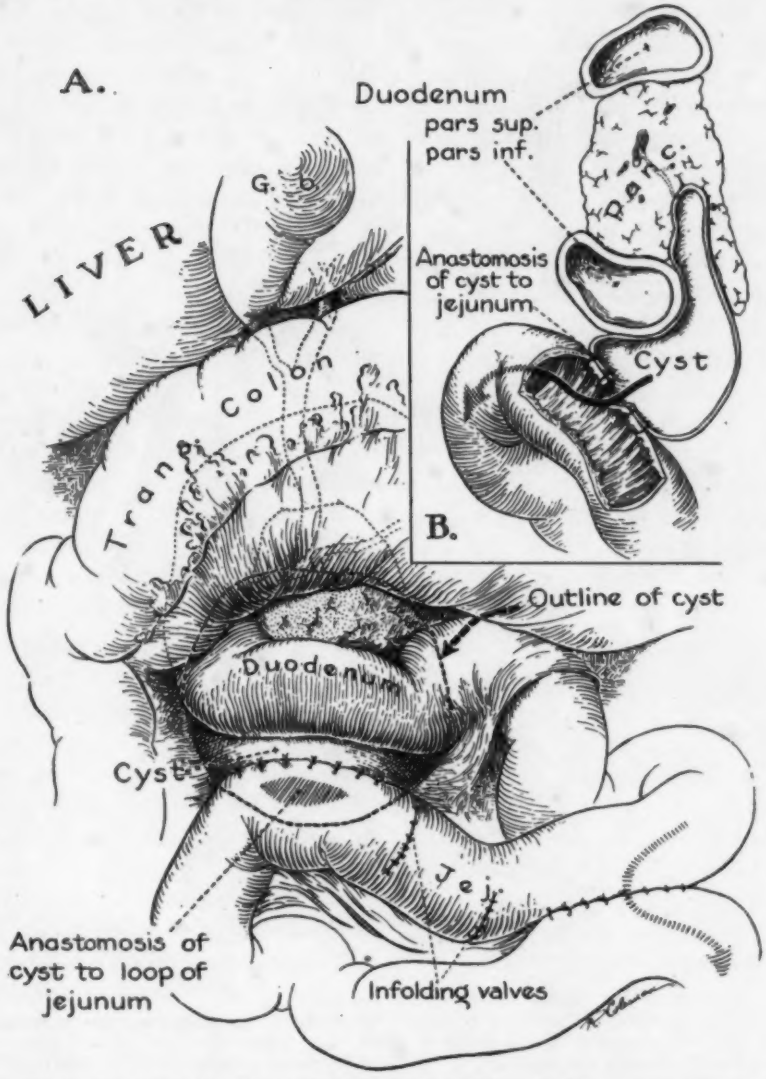


FIG. 4.—In case 4 a small cyst (6 by 7 cm.) of the head of the pancreas presented posteriorly and inferiorly, thus making marsupialization impossible. Anastomosis of the cyst to a defunctionalized loop of jejunum has relieved all symptoms.

tween the anastomosis and the liver. From our perusal of the literature, we have not encountered any instances of infection in the liver (suppurative cholangitis) or in the cyst locally after such anastomoses.

However, since it takes only a few minutes longer to anastomose the cyst to a loop of jejunum, the arms of which are connected by means of an enteroenterostomy (fig. 3), we recommend this additional pre-

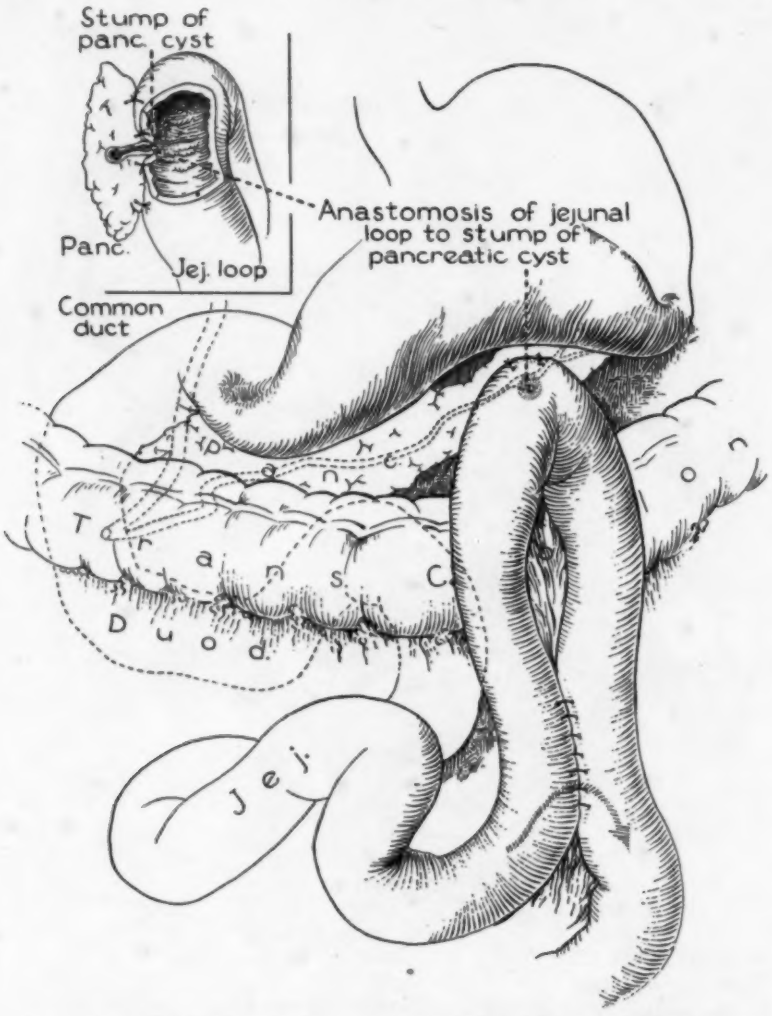


FIG. 5.—In case 5 a pancreatic cyst in the body of the pancreas was marsupialized, but the resultant fistula failed to close. The sinus tract was excised and the stump of the fistula anastomosed to a loop of jejunum as illustrated. An anastomosis was performed between the two loops of jejunum to obviate obstruction, but no folds were made in the ascending limb of jejunum because reflux over the fistula would be inconsequential.

caution. Furthermore, since regurgitation can take place into the proximal arm of the loop without passing through the area of the enteroanastomosis, we recommend that two folds, as illustrated in

figure 7, be taken in the proximal arm. In our series of cases roentgenologic examination has not revealed any regurgitation past folds of this type.

Pancreatic cysts are usually marsupialized, since three-fourths of them will be obliterated without the formation of fistulas after this procedure. However, occasionally the pancreatic cyst will be small or located in an awkward position for marsupialization, as occurred in case 4. In this case the cyst was only 5 or 6 cm. in diameter and was located in the posteroinferior portion of the head of the pancreas. Marsupialization was impossible in this case because the cyst was small and presented posteriorly; the cyst was anastomosed to a loop of jejunum as illustrated in figure 4. Anastomosis of a pancreatic cyst to a loop of jejunum is by no means a new procedure, the operation having been performed first in 1923 by Henle[5]. However, as far as we can determine it has not previously been reported that folds were placed in the proximal loop to prevent regurgitation. When a marsupialized pancreatic cyst forms a fistula which fails to heal, the latter may be transplanted into the intestine, as has been performed by numerous surgeons. Since there is no significant tissue to become infected by exposure to the food stream, we recommend anastomosis to a loop of jejunum (with enteroanastomosis to protect against possible obstruction at the anastomotic site but without folds to prevent regurgitation [fig. 5]).

There has been considerable discussion in the medical literature as to whether or not anastomosis of the duodenum to the gallbladder for obstruction produced by carcinoma of the pancreas gives rise to cholecystitis, but no definite conclusion has as yet been reached on this point. However, all surgeons would probably agree that if infection of the gallbladder does occur it does not develop to a degree which is demonstrable clinically during the few remaining months which the patients live. When anastomosis between the gallbladder and the intestine is to be performed as a palliative procedure, a classic cholecystoduodenostomy would appear to be perfectly safe and the procedure of choice. On the other hand, if such an anastomosis is being performed for a benign obstruction of the stricture type, we recommend anastomosis of the gallbladder to a loop of jejunum, with enteroenterostomy and folds in the proximal loop as illustrated in figure 6. However, we are by no means convinced that this is a good operation for benign obstruction. For example, the patient illustrated in figure 6 (case 6) had cholic stools after cholecystojejunostomy, but he remained jaundiced for four months after operation. Evidently

5. Henle, cited by Hahn, O.: Beitrag zur Behandlung der Pankreascysten, Zentralbl. f. Chir. **54**:585-588, 1927.

the cystic duct was of insufficient size to give adequate biliary drainage. Another operation appeared indicated early in his postoperative course, but when he was last seen two months later the jaundice had

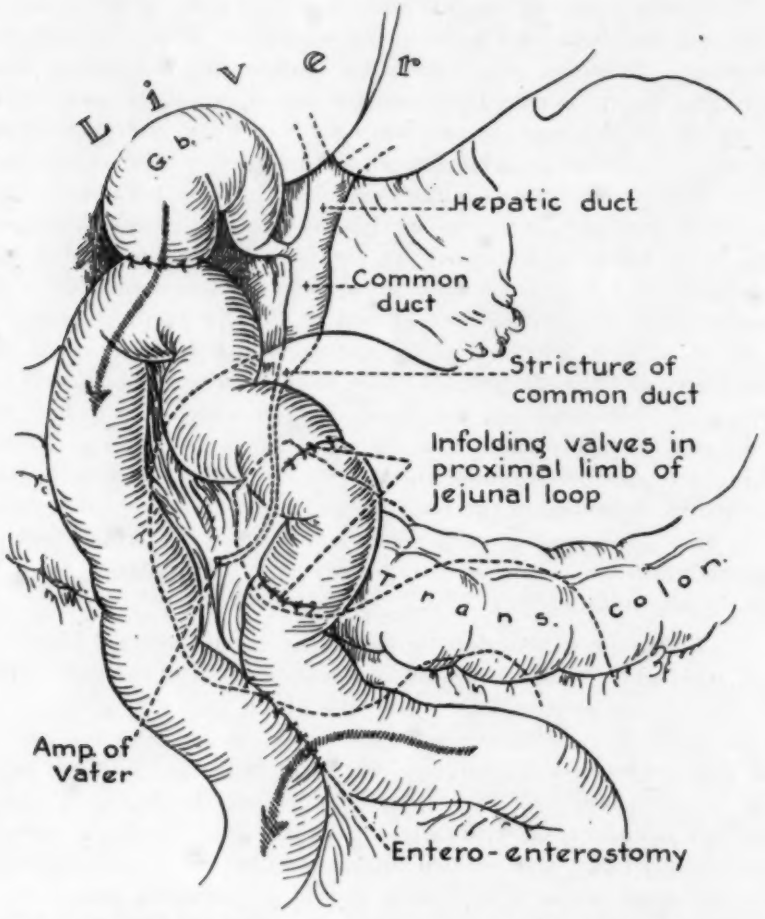


FIG. 6.—The patient in case 6, had a stricture of the distal end of the common duct, for which a cholecystenterostomy was performed as illustrated. An enteroenterostomy was performed and folds constructed in the proximal arm to prevent passage of food and intestinal secretions into the gallbladder.

almost completely disappeared. It therefore appears that he will need no additional surgical treatment.

## REPORT OF CASES

*Case* 1.—M. F., a 57 year old white woman, was admitted to Illinois Research and Educational Hospital on Jan. 29, 1942, with a history of jaundice and acholic stools which began suddenly after a cholecystectomy performed four years before.

She was reexamined at that time, and a T tube was put in the strictured bile duct. Symptoms reappeared, and a loop of jejunum was anastomosed to the common duct over a T tube. Four months after removal of the T tube she began having attacks of chills and fever, with the temperature frequently going up to 103 to 106 F. On her entrance in the Illinois Research Hospital examination revealed a poorly nourished patient appearing chronically ill. Through an incisional hernia in the right upper quadrant an enlarged tender liver could be palpated. Laboratory data were noncontributory except for an icterus index of 27. At operation a stenosis was found at the site of the anastomosis between the common duct and the loop of jejunum. A rubber catheter was inserted, with immediate decrease of the spiking temperatures. Symptoms again recurred, and a "vitallium" tube was implanted on Jan. 15, 1943, as illustrated in figure 2*A*. When symptoms of ascending cholangitis again developed, barium was given by mouth and found to flow freely into the biliary radicles, as shown in figure 1*A*. Therefore she again was admitted to the hospital, and on October 2 the proximal limb of the loop of jejunum was severed, as illustrated in figure 2*B*. Since that time the patient has been well and has had no roentgenologic or symptomatic evidence of regurgitation of intestinal content into the biliary tree.

*Case* 2.—A 54 year old white woman entered Illinois Research and Educational Hospital on April 22, 1942, complaining of jaundice, light-colored stools, dark urine, generalized pruritus and epigastric distress of one month's duration. She had had episodes of similar complaints ever since her gallbladder had been removed at another hospital, but all symptoms would clear (except for light-colored stools) when the postoperative biliary fistula would open. These attacks were frequently associated with chills and fever.

Examination revealed slight tenderness of the liver and an icterus index of 81. On May 4, 1942 a complete stenosis of the common bile duct was found at operation, and no distal remnant of the duct could be located. The hepatic duct at the hilus was anastomosed to an isolated loop of jejunum over a "vitallium tube," as in figure 2*A*. The patient was completely relieved of symptoms for a period of one year, after which time she started to have episodes of chills and fever at about weekly intervals, each of which would keep her ill in bed one day or more. Roentgenologic examination at this time revealed the fact that barium given by mouth went through the anastomosed area into the biliary radicles, as illustrated in figure 1*B*. She therefore reentered the hospital on Jan. 15, 1944; on January 28 she was reoperated on, and the proximal limb of the anastomosed loop was severed (fig. 2*B*). A flap type valve was constructed in the distal limb of the loop.[6] Since that time the patient has been free from the episodes of chills and fever, and reexamination with barium shows that regurgitation does not take place.

*Cas* 3.—B. T., a 36 year old white woman, was admitted to Illinois Research and Educational Hospital on Jan. 10, 1946, complaining of epigastric distress, frequently radiating through to her back, associated with chills and fever coming on in attacks lasting from one to four hours and usually terminating with nausea and vomiting. She had had these attacks during the previous fifteen months up to two or three times a week. For three months she had noticed a tender mass in the upper part of the abdomen, slightly to the right of the midline. She entered another hospital on Jan. 7, 1946, and disease of the gallbladder was diagnosed. A laparotomy was performed two days later; a cyst in the upper abdominal area was found and the abdomen closed. Physical examination at Research and Educational Hospital

6. We are now certain that folds or valves are not necessary in a loop in which the peristaltic waves carry food or secretions away from the gallbladder.

revealed a fairly well developed white woman not acutely ill. A tender mass about 12 cm. in diameter was readily palpable in the upper part of the abdomen underneath the right rectus incision. Jarring or percussion in this area would produce pain. A roentgenologic examination of the gastrointestinal tract with barium showed displacement of the distal end of the stomach anteriorly, with the duodenum widened and flattened by a tumor mass in the region of the head of the pancreas. Chemical examination of the blood gave findings which were within the limits of normal, including the icterus index and the serum amylase content.

At operation on Feb. 15, 1946, a cystic mass as described previously was found under the pylorus; it was pushing the stomach forward and presenting itself between the stomach and the transverse colon. When the gastrocolic omentum was opened, the cyst was found to be covered with a thin layer of pancreas. On aspiration of the cyst, dark turbid bile was obtained, culture of which revealed hemolytic Staphylococcus aureus. It would have been impossible to mobilize the cyst for marsupialization, and it was felt that the treatment of choice was an anastomosis of the cyst to the gastrointestinal tract; therefore an area of pancreas over the cyst was incised and the cyst anastomosed to a defunctionalized loop of jejunum as in figure 3.

*Case* 4.—T. S., a white man aged 62, was admitted to Illinois Research and Educational Hospital on Aug. 23, 1944, complaining of diffuse aching pain in the upper abdominal area, loss of appetite, nausea and vomiting of two and a half months' duration. He lost 35 pounds (16 Kg.) in weight during the preceding six months and had progressive weakness. He had complained of dyspnea, heartburn and belching for thirty years and had a perforation of a duodenal ulcer nineteen years previously. Fifteen years ago he had undergone a gastroenterostomy for a stenotic duodenal ulcer. This relieved his symptoms for two years, and then he had recurrent attacks of severe dyspepsia three or four times a year (mainly in spring and fall). These attacks were characterized by a constant severe pain in the upper abdominal area not related to meals and not relieved by food or soda. He lost his appetite, became nauseated and frequently vomited in spite of a small food intake. The vomitus often contained streaks of blood, and the patient had one or two tarry stools during the two months before his admission to the hospital.

Physical examination revealed a poorly nourished, chronically ill patient with a blood pressure of 100 systolic and 80 diastolic. The abdomen was scaphoid and had scars from a right rectus and a McBurney incision. There was slight epigastric tenderness but no abdominal masses were palpable. His blood count, including the differential, was normal, as was the blood on chemical examination. The patient had no gastric residuum, and the analysis of the gastric contents revealed them to be normal. Roentgenologic examination of the gastrointestinal tract showed a well functioning gastroenterostomy opening, but there was an area of marked irregularity in the jejunal loop. This irregularity was constant and pouchlike in shape and was interpreted as a jejunal ulceration. An operation was performed on Oct. 2, 1944, and adhesions alone were found to be causing the jejunal deformity. However, a tumor mass about 6 cm. in diameter was found in the head of the pancreas projecting downward and posteriorly. Marsupialization was impossible, and a loop of jejunum distal to the gastroenterostomy opening was anastomosed to the cyst as illustrated in figure 4, with uneventful recovery of the patient and relief of symptoms.

*Case* 5.—H. S., a white man aged 47, first entered Illinois Research and Educational Hospital on April 11, 1940, at which time he complained of jaundice and pain in the right upper abdominal quadrant of six months' duration. His stools had become light in color, and he complained of severe pruritus. Physical examina-

tion revealed jaundice and moderate emaciation. The upper part of his abdomen was distended by a mass about 10 cm. in diameter. Roentgenologic study revealed this mass to be displacing the pyloric end of the stomach upward and the first and second portions of the duodenum laterally and anteriorly so that the duodenum made a wide arc around the mass. Laboratory examinations were noncontributory except that a red blood cell count of 3,900,000 and an icterus index of 42 were revealed. At operation a large cyst was found in the body of the pancreas, which was marsupialized. The postoperative course of the patient was uneventful, with the complete relief of both the abdominal pain and the jaundice, but subsequent persistence of the pancreatic fistula necessitated his rehospitalization two years later, at which time the stump of the fistula was transplanted into a defunctionalized loop of jejunum as illustrated in figure 5.

*Case* 6.—A white man, aged 61, entered Illinois Research and Educational Hospital on April 11, 1946, complaining of large, foul, bulky stools, diarrhea and an enormous appetite of two years' duration. Four months prior to his admission the patient noted weakness along with progressive jaundice, darkening of urine and acholic stools. Physical examination revealed a fairly well developed, poorly nourished white man with obvious jaundice of the skin and scleras. The liver was down three fingerbreadths and smooth. Laboratory examination revealed a red blood cell count of 4,500,000, a white blood cell count of 6,700, an icterus index of 160, bile in the urine and much undigested fat in almost acholic stools. His course in the hospital was complicated by an infection of the urinary tract. As this came under control chills and fever developed, with an increase in icterus; an emergency choledochostomy was performed on May 25, 1946. At this time is was questionable whether or not the probe passed through the papilla of Vater into the duodenum. The gallbladder was normal, and green bile was obtained from the duct. A T tube was sutured in place. The common duct did not open postoperatively, and reexploration was carried out on Oct. 8, 1946. At this time there was no doubt about the pathologic condition present. The distal end of the common duct was stenosed by a chronic sclerosing pancreatitis. The common hepatic duct was not involved at the junction with the cystic duct, so the gallbladder was utilized in the anastomosis with a loop of jejunum, as shown in figure 6. After this operation, bile appeared in the stools, but jaundice persisted for four months. When the patient was last seen six months after the cholecystojejunostomy, the icterus was almost gone; another operation will presumably be unnecessary.

## ANIMAL EXPERIMENTS

The ultimate fate of the valves constructed in our human patients was not known to us inasmuch as we did not have the misfortune of needing to reoperate on any of them. For that reason a series of animal experiments were performed.

Valves in the proximal limb of the isolated loops of jejunum of dogs were constructed in two ways, as illustrated in figures 7 and 8.

Seven dogs were used in this experiment. With the dogs under general anesthesia, an enteroenterostomy was performed on each, producing an isolated loop of jejunum 30 to 40 cm. long. In 3 of the animals a flap type of valve as well as an infolding valve was constructed (figs. 7 and 8). In 2 cases one flap type valve was made and in 2 one infolding type of valve. Accordingly, five valves of each type were constructed and were examined and photographed at intervals of from two to eight months after operation.

RESULTS

When first constructed, the flap valve (fig. 8*A*) measured 1 cm. wide and .5 cm. long. However, by the end of a three month period

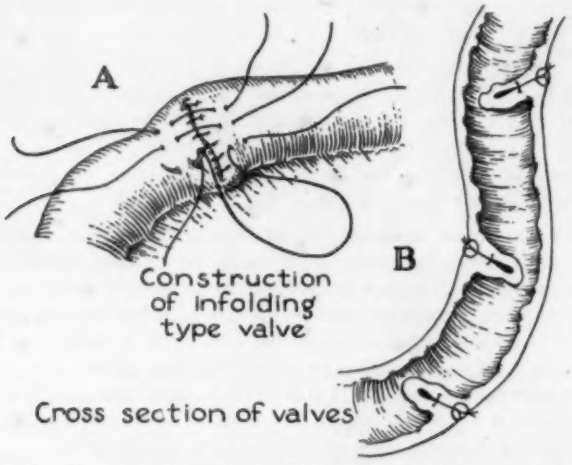


FIG. 7.—Folds constructed in the small intestine of dogs as in *A* were found to be unchanged (as in *B*) when examined one to eight months later.

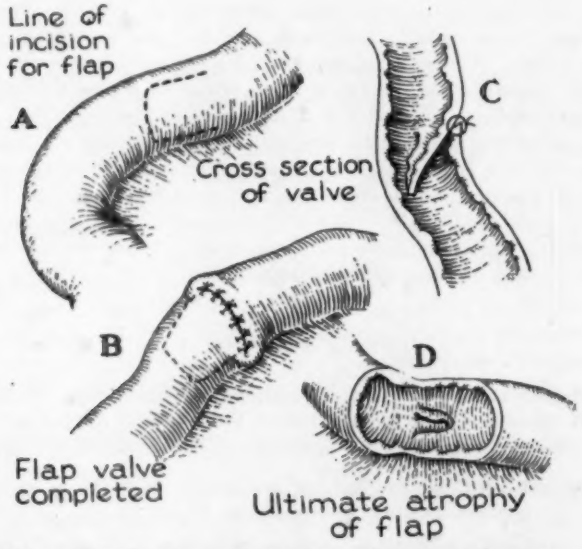


FIG. 8.—Flaps made in the small intestine of dogs as shown in *A*, *B* and *C* atrophied to a small nubbin as shown in *D* within a few weeks or months, which indicated their worthlessness as valves.

it had atrophied into a small cylindric nubbin of tissue (fig. 8*D*) 3 mm. in diameter and 5 mm. long and covered with mucosa. In

itself it did not appear to be able to act to any degree as a valve, as we originally intended.

However, the simple inversion type of folds or valves as illustrated in figure 7 retained their size and character over the eight month period during which they were observed. It therefore appears that the inversion valve or fold could definitely act as an obstruction to mas-

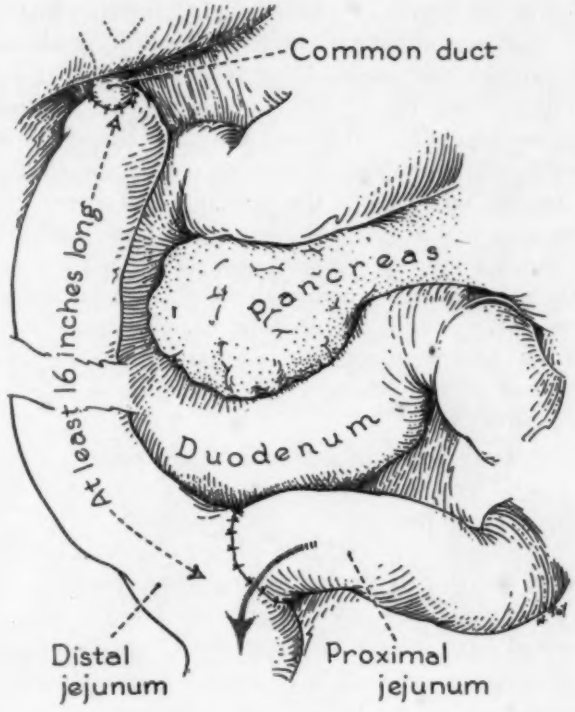


FIG. 9.—An arm of jejunum known as the Roux Y arm is now being used widely to connect the common duct with the intestine after resection of the head of the pancreas and operation for stricture of the common duct. No folds need be constructed in this arm of jejunum if it is at least 16 inches (41 cm.) long because regurgitation will not progress far against peristalsis.

sive regurgitation of food and would not interfere with the downward flow of bile.

Since our animal experiments revealed so much shrinkage of the flat type of valve, we now utilize only the infolding type of valve in patients. No originality is claimed for the construction of these valves, since valves of this type and many others have been described by numerous investigators.

SUMMARY

Early in our experiences with repair of strictures and with absence of the common duct we noted that anastomosis of the hilar bile duct to a loop of jejunum relieved the obstruction of the bile duct but that on most occasions suppurative cholangitis (sometimes followed by abscess of the liver) ultimately developed. Roentgen examination utilizing barium revealed that there was a reflux of barium up the proximal arm of jejunum into the intrahepatic bile ducts even though we had performed an enteroenterostomy as shown in figure 2*A*. In 2 patients the proximal or ascending loop of jejunum was severed and the ends turned in. This procedure resulted in immediate cessation of chills and fever, and the patients have remained asymptomatic ever since (four and three years respectively). This observation has led us to adopt the principle of constructing valves or folds in the proximal arm of the loop of jejunum leading to an anastomosis between a loop of jejunum and such structures as pancreatic cysts and the gallbladder even though an anastomosis is made between the two arms of jejunum. At no time have we noted any regurgitation of barium (during roentgen examination) up the proximal loop of intestine past such folds or valves through the stoma connecting the intestine with cysts.

Use of the Roux Y arm of jejunum for anastomosis to the common duct as practiced by numerous surgeons for strictures of the common duct or resection of the head of the pancreas (fig. 9) has proved satisfactory. Although we originally placed one or two folds or valves on this arm of intestine to prevent regurgitation, we are now convinced that they are unnecessary, particularly since any reflux of food or secretion would have to take place against the peristaltic mechanism.

When cholecystenterostomy is performed for inoperable carcinoma of the pancreas, we do not believe that it is necessary to modify and lengthen the operation by construction of folds or valves, since the patient will probably die before symptoms of suppurative cholangitis can develop. However, when the small intestine is anastomosed to the gallbladder or other structures for benign lesions, we recommend construction of two or three folds in the proximal arm of jejunum even though an enteroenterostomy is performed.

In animal experiments performed by one of us (L. P.) we noted that the flap type of valve (fig. 9) atrophied to such a great extent that function as a valve would appear impossible. On the other hand, folds constructed as in figure 7 remained without evidence of atrophy or other significant change for at least eight months.

# RECOVERY OF SENSATION IN SPLIT THICKNESS SKIN GRAFTS

## A Study of One Hundred and Eighty-Seven Cases

GRAHAM A. KERNWEIN, M.D.
MINOT, N. D.

A REVIEW of the medical literature reveals few reports of studies concerning the recovery of sensation in skin grafts. All agree that, under favorable conditions of growth recovery of sensation in pedicle skin grafts begins at the periphery in the region of the proximal nerve supply and spreads distally. There is a temporal dissociation in the appearance of recovery. Pain sensation appears in three to six months and usually goes on to completion within a year. Touch returns in nine to twelve months, and temperature discrimination lags behind. Adequate recovery of sensation in a pedicle graft usually is followed by recovery of sympathetic innervation.

Review of the reports of studies dealing with recovery of sensation in split thickness skin grafts reveals that there are two opinions, diametrically opposed. Prior to McCarrol's[1] report, recovery of sensation in split thickness grafts is described as patchy and incomplete and the rate of recovery as directly proportional to the thickness of the graft[2]. It is said that recovery of sympathetic innervation does not occur[3]. McCarrol reports, however, that his studies show exactly the opposite, i.e.,[5] that "complete recovery of sensation in all types of grafts is possible to an equal degree unless the cutaneous nerves in the involved region have been completely destroyed and have failed to regenerate" and that "the rate of return is inversely proportional

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Read at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

1. McCarroll, H. R.: The Regeneration of Sensation in Transplanted Skin, Ann. Surg. **108**:309, 1938.

2. Kredel, F. E., and Evans, J. P.: Recovery of Sensation in Denervated Pedicle and Free Skin Grafts, Arch. Neurol. & Psychiat. **29**:1203, (June) 1933. Davis, J. S., and Traut, H. F., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., 1931, vol. 5, chap. 8. Williams, G. A.: End-Result in Thiersch Graft: A Case Observed After Thirty Years, Arch. Surg. **16**:938, (April) 1928. Davis, L. E.: The Return of Sensation to Transplanted Skin, Surg., Gynec. & Obst. **59**:533, 1934.

3. Kredel, F. E., and Phemister, D. B.: Recovery of Sympathetic Nerve Function in Skin Transplants, Arch. Neurol. & Psychiat. **42**:403 (Sept.) 1939.

to the thickness of the graft used in the three types which were studied" (split thickness, full thickness and pedicle).

Our interest in this problem was aroused when sores developed in an otherwise excellent split thickness skin graft seven and one-half months old as a result of friction of the heel in a new shoe (fig 1). The graft had been used to fill a soft tissue defect overlying the achilles tendon and resulting from a wound from a high explosive shell. Examination revealed that it was pliable and readily movable over the underlying tissues and that it possessed an excellent circu-

FIG. 1.—Split thickness skin graft seven and a half months old. The graft directly overlies the achilles tendon, to which it is not attached. Regions *A* and *B* are healing ulcers. The graft is devoid of sensation, a fact not appreciated when the patient attempted to wear shoes. Because of lack of pain, he did not realize that the shoe rubbed, and pressure sores resulted that required six weeks to heal.

lation but was entirely without sensation. Accurate information concerning the recovery of sensation in this type of graft and the factors that influence it are of extreme practical importance.

## MATERIALS AND METHODS

Pinprick stimulation was affected with the aid of an algesimeter described by Pollock.[4] It consisted of a large-headed pin in the barrel of a glass syringe, the

4. Pollock, L. J., and Davis, L.: Peripheral Nerve Injuries, New York, Paul B. Hoeber, 1933, p. 35.

point of which was allowed to extend through the tip and displace the plunger. The weight of the plunger determines the degree of pressure when the pin is allowed to prick the skin with the syringe held by the barrel.

As Cobb[5] has pointed out that apparent dissociation in recovery of sensation in lesions of peripheral nerves arises from comparison of stimuli which are

*Results of Experiment on Recovery of Sensation*

| No. of Days | No. of Cases | Pressure | Sensation Pinprick with Algesimeter Exerting Pressure of | | | Light Touch | Temperature |
|---|---|---|---|---|---|---|---|
| | | | 34 Gm. | 14 Gm. | 4 Gm. | | |
| 10 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 28 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 30 | 4 | 2 | 2 | 1 | 0 | 0 | 0 |
| 33 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 37 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 38 | 2 | 1 | 1 | 1 | 0 | 0 | 0 |
| 39 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 40 to 50 | 14 | 11 | 11 | 11 | 4 | 3 | 4 |
| 50 to 65 | 29 | 27 | 27 | 27 | 6 | 6 | 6 |
| 84 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 99 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 147 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 175 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 185 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 187 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 253 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 269 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 292 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 305 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 326 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 354 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 362 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 387 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 394 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 399 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

quantitatively unequivalent, it was decided to use algesimeters of different weights (34, 14 and 4 Gm.). In this way it was hoped that a basis for establishing a quantitative equivalent for the various sensory stimuli might be established.

5. Cobb, S.: Cutaneous Sensibility in Cases of Peripheral Nerve Injury: Epicritic and Protopathic Hypothesis of Head Untenable, Arch. Neurol. & Psychiat. **2**:505 (Nov.) 1919.

Tactile sensibility was tested with a wisp of cotton. Temperature sensation was tested with a cotton pledge moistened with ether.

One hundred and eighty-seven patients were examined. Seventy-four split thickness skin grafts were considered comparable to those reported by McCarrol. The criteria used in selecting the cases were: (*a*) A 95 to 100 per cent "take" of skin graft; (*b*) pliable graft, easily movable over underlying tissues; (*c*) a graft bed composed of subcutaneous tissues or a donor site of pedicle graft, and (*d*) a surrounding skin which was normal in texture and sensation.

In order to study the effect of scar tissue on recovery of sensation, 22 patients with grafts varying in age from eight to fifteen months were selected for study,

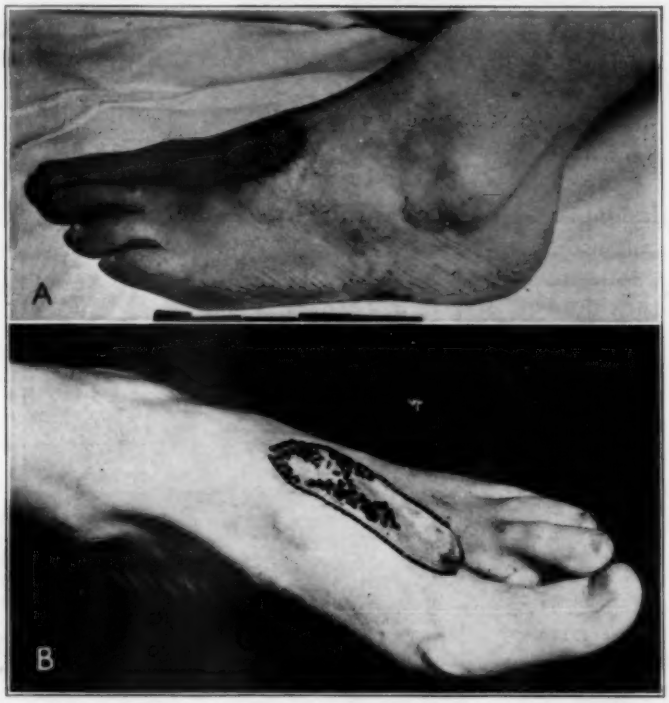


FIG. 2.—*A*, split thickness skin graft ten days after operation. Dots indicate region of beginning recovery of pain as indicated by sensation of pinprick with 34 Gm. algesimeter. *B*, same graft seventeen days after operation. Dots show marked increase in amount of recovered sensation. This is one of the few cases in which the recovery began predominately at the periphery.

either because the graft lay in the center of a huge insensitive scar or because it was firmly adherent to the underlying base of bare bone, tendon or muscle.

The effect of loss of nerve supply was studied in three series of cases. One series consisted of 18 cases in which split thickness grafts were transplanted to the donor site of a pedicle graft with normal surrounding skin. The second consisted of 23 cases in which there were split thickness grafts with anesthesia of the surrounding skin and the third consisted of 29 cases in which the subcutaneous tissue and the deep fascia had been destroyed, thereby indicating loss and damage to

local nerve supply. The skin graft was movable over the underlying tissue, however, and in some there was a band of anesthesia in the skin distal to the graft.

## RESULTS

In the accompanying table there are recorded the results found in 74 cases considered comparable to those reported by McCarrol. Beginning recovery of sensation as early as the tenth day is present in only 1 case. In this instance the sensation first appeared at the periph-

FIG. 3.—*A*, split thickness skin graft eighty-four days after operation. The graft was applied to a region denuded by a phosphorus burn. In the solid-colored patches pain sensation is elicited with a 14 Gm. algesimeter. In the circled and dotted patches light touch and temperature sensation also are demonstrable. This patchy pattern is typical for split thickness grafts. *B*, split thickness graft one hundred and seventy-five days old. Dots show isolated patches of sensation (pinprick) caused by the 34 Gm. algesimeter. Elsewhere the graft is anesthetic. Touch and temperature sensation are absent. *C*, split thickness graft sixty days old. Pain caused by the 4 Gm. algesimeter, touch and temperature sensations all are present in the dotted area. Elsewhere the graft is anesthetic. Note that patch *A* appears in graft at level where the deep peroneal nerve bends a sensory branch to the skin. Stimulation of region *B* also gives rise to an unpleasant painful sensation referred to the heel.

ery and extended distally so that by the seventeenth day about one third of the graft had regained sensation (fig. 2).

A soldier sustained a gunshot wound of his left foot, with a compound, comminuted fracture, of the second metatarsal bone. The wound healed by secondary

intention, but there was a resultant painful cicatrix. The scar was excised and a split thickness graft from the thigh applied to the denuded area. Figure 2*A* shows the amount of sensation present on the tenth postoperative day, with the increase by the seventeenth day depicted in figure 2*B*. This case is an exception, as in the majority (76 per cent) it is seven to nine weeks before beginning recovery of sensation is observed.

### PATTERN OF RECOVERY

Regeneration of sensation universally appeared in isolated patches. Characteristically, the size of the patches increased at the periphery and the threshold for pain gradually decreased in the central portion.

FIG. 4.—*A*, split thickness graft one hundred and thirty-seven days old. Graft is firmly adherent to underlying tissues. The scar tissue has effectively blocked the ingrowth of nerves, and the entire graft is without sensation. *B*, split thickness skin graft one hundred and fifty-seven days old. The graft is firmly adherent to the underlying muscle. Sensation is absent, demonstrating the effective blocking of ingrowing nerves by the scar tissue at the junction of the graft with muscle.

In the beginning only the pressure exerted by a 34 Gm. algesimeter is identified as pinprick. Next the pressure from the 14 Gm. algesimeter and finally that from the 4 Gm. algesimeter are identified. When the last is identified, sensations of light touch and temperature sensations also are demonstrable. There is, therefore, a definite temporal dissociation of pain sensation. Although the patches increase in

size about the periphery, there remain large regions of skin that are devoid of sensation as they usually do not coalesce. None, therefore, may be said to regain sensation equal to that of the surrounding normal skin. Figure 3 depicts the findings in 3 cases which are con-

FIG. 5.—*A*, split thickness graft one hundred and sixty-three days old. The bed of this graft is devoid of subcutaneous tissue and deep fascia. However it is freely movable over the underlying tissues. Thus there is no scar tissue block to the ingrowth of nerves. Beginning recovery of sensation is attested by the disseminated patches of sensation depicted by the dots. *B*. split thickness graft one hundred and seventy-three days old completely surrounded by dense scar tissue. In the patches of sensation in the graft pain from the 4 Gm. algesimeter and touch and temperature sensations are present. The sensation in the graft is definitely more acute than that in the scar. *C*, split thickness skin graft one hundred and forty-seven days old. The graft is pliable and freely movable over underlying soft tissues in the periphery, where patches of sensation are present. In the central region the graft is firmly attached to the patella and is devoid of sensation. Grafts implanted on a bed of bare bone remain anesthetic indefinitely.

sidered typical of those in which the graft lies on a good layer of subcutaneous tissue, over which it is easily movable, and the sensation of the surrounding skin is normal. The patchy nature of distribution indicates that the ingress of nerve fibers supplying sensation to the

graft must occur from below. This is further attested by the findings depicted in figures 7 and 11. These grafts are transplanted over regions in which the cutaneous sensation comes from mixed nerves. Patches of sensation are found in the graft at the points where the sensory branches become superficial.

### EFFECT OF SCAR TISSUE BASE ON RECOVERY OF SENSATION

Dense scar tissue, such as that which occurs when a graft becomes firmly adherent to the underlying structures, will block the ingrowth of nerve fibers. Figure 4 depicts 2 typical cases, in both of which the grafts are completely anesthetic. Figure 5*A* shows a graft which

FIG. 6.—Pedicle of skin *A* has both ends still attached and sensation intact. The donor site is covered with a split thickness graft, *B*, as is the raw under surface of the pedicle *C*, both split thickness grafts are seventy-four days old, and sensation is absent. Delay in recovery of sensation in *B* is due to absence of cutaneous nerves. Whether sensation ever would develop in skin graft *C* is unknown.

was transplanted to a region devoid of subcutaneous tissue and deep fascia but which did not become attached to the underlying muscles. The absence of a dense layer of scar tissue permits the deep-lying mixed nerves to send cutaneous filaments to the graft. The finding of sensation in this graft refutes the theory that failure to obtain recovery of sensation in the grafts attached to their base is due to the absence of cutaneous nerves. Further evidence that deep-lying nerves may send branches to an overlying graft is found in skin grafts transplanted into the center of dense scar tissue. Figure 5*B* depicts the

recovery of sensation in such a graft. The pattern is patchy, but the sensation in the patches is definitely more acute than that in the surrounding scar. Split thickness grafts transplanted over bare bone or large expanses of tendon remain anesthetic.

In a series of 26 cases in which the split thickness grafts were applied directly to bone and varied in age from six to fourteen months there was no evidence of recovery of sensation. The findings in one such skin graft transplanted over the anterior portion of the knee joint are depicted in figure 5*C*. About the periphery of the graft the skin is pliable and easily movable over the underlying structures, and there are patches of recovered sensation. In the central portion, where the graft is firmly adherent to the underlying patella, sensation is absent.

### EFFECT OF DESTRUCTION OF CUTANEOUS NERVES ON RECOVERY OF SENSATION

McCarrol stresses the fact that recovery of sensation is earliest and conditions for growth most favorable in regions with a good layer of subcutaneous tissue and an intact nerve supply. The delay resulting from disturbances of local nerve supply is readily demonstrable in split thickness grafts applied to the donor site of a pedicle graft. Figure 6 shows a pedicle graft in the act of being raised but with both ends still attached. Sensation in this bridge of skin is normal, which indicates that the cutaneous nerves have been raised with the pedicle and that the donor site is without cutaneous nerves. A pliable split thickness graft that fulfils all the critera used in the selection of the cases in the accompanying table covers the donor site, and another split thickness graft covers the raw under surface of the pedicle. Seventy-four days after operation both grafts were completely anesthetic. The failure to recover sensation in the former is due to lack of local nerve. A delay in similar circumstances was found in all 19 cases studied. The split thickness graft applied to the raw under surface of the pedicle lies on a good layer of subcutaneous fat with an intact nerve supply. Despite a 100 per cent "take" it also is anesthetic. One must conclude that as the branches from the cutaneous nerves supplying sensation to the skin are intact and have never been cut they lack the necessary stimulus to send new fibrils out into a skin graft such as that applied to the raw under surface.

A total of 19 cases were studied in which pedicle grafts had been used and the donor site covered with a split thickness graft. In every instance the rate of recovery was more rapid the pattern more regular and the amount of recovery more nearly complete in the pedicle graft. Because of the pronounced similarity, 5 cases are presented in detail. In each instance a pedicle graft from the chest wall was trans-

ferred to the upper extremity and a split thickness graft used to cover the donor site.

Errors due to evaluation of sensory stimuli are minimized by testing for recovery of sensation in a split thickness graft and in a pedicle graft in the same person. As essentially the same nerves are involved the tendency for growth should be comparable, and as essentially the same regions are involved the threshold stimuli should be similar.

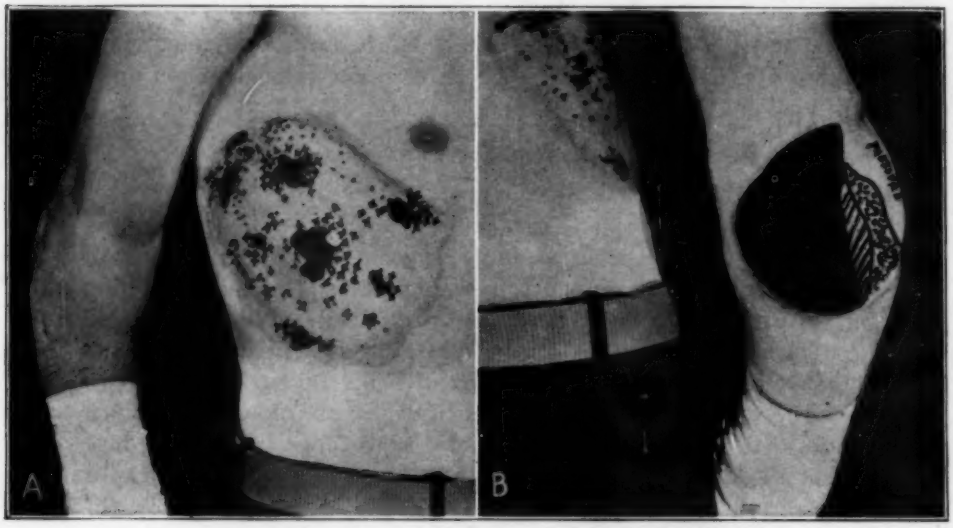


FIG. 7.—*A*, split thickness graft three hundred and three days old applied to donor site bed. In the solid-colored areas sensation from the 4 Gm. algesimeter and touch and temperature sensations are present. In the area outlined with X's pain from the 14 Gm. algesimeter is present and in the dotted region pain with the 34 Gm. algesimeter. Elsewhere sensation is absent. The patchy yet segmental distribution of the sensation conforms to the known anatomic distribution of sensory branches arising from the intercostal nerves. The first sensation appeared in the third month. Each patch gradually increases in size about the periphery. Finer discrimination appears only in regions in which pain previously has been present. Such patches must result from invasion of graft by underlying sensory nerves. *B*, pedicle skin graft three hundred and three days old. Sensation is present in two thirds of the graft. Recovery first appeared on the mesial side in the third month. In the solid area pain from the 4 Gm. algesimeter and touch and temperature sensations are present. The pressure from the 14 Gm. algesimeter is appreciated in the striped area and that from the 34 Gm. algesimeter in the dotted area. Elsewhere only pressure sense is present. This pattern is typical for pedicle grafts. It suggests that recovery of sensation in these grafts is due to their invasion from the surrounding tissue by nerves whose course is parallel to the surface of the graft.

*Case* 1.—A huge pedicle flap was raised from the chest wall and transplanted to the posterior surface of the right arm and a split thickness graft was transplanted to the donor site on the chest. Figure 7 shows the findings three hundred and three days after operation. The pattern of recovery in the pedicle graft is typical. Evidence of beginning recovery of sensation is seen at the periphery at the proximal border and over more than half of the graft. The gradation in sensation is depicted.

In the solid area the pressure from the 4 Gm. algesimeter is identified as pinprick and touch and temperature sensations are present. In the striped area the prick from the 14 Gm. algesimeter is identified, and in the dotted area only the prick from the 34 Gm. algesimeter is identified. Distal to this, in the unmarked portion, the latter is identified only as pressure. The pattern of recovery in the split thickness graft is patchy. In the central "solid" area the pressure from the 4 Gm. algesimeter is identified, and touch and temperature sensations are present. About the periphery, in the region limited by the X's, the pressure from the 14 Gm. algesimeter is recognized. The large intervening unmarked regions are anesthetic. The intercostal nerves run along the inferior margin of the rib, and at a point midway between the vertebral column and the sternum they send a perforating sensory branch to the skin. This latter nerve divides, sending one branch dorsally and the

FIG. 8.—*A*, one hundred and eighty-five day old split thickness graft to donor site of pedicle graft. Dots indicate pattern of recovery of pain sensation. *B*, comparison of amount of recovery of sensation in pedicle graft *A* on arm and in split thickness graft *B* on abdomen. Both grafts are three hundred and seventy-eight days old. Sensation of pedicle graft *A* essentially is equal to that of the normal skin except in the region of the recently healed, surgically incised wound. Recovery of sensation in the split thickness graft is incomplete. Dorsal to the black line temperature and touch sensations are present; ventrally in dotted area only pain is present. Sensation is absent in the unmarked region.

other ventrally. A second perforating branch is given off just before the intercostal nerve comes to the sternum. The pattern of recovery of sensation in the huge split thickness graft in figure 7 *A* corresponds to the sensory distribution of the underlying intercostal nerves.

*Case* 2.—A pedicle flap was raised from the chest wall to the arm, with a split thickness skin graft to the donor site at the same time. Five months later bone graft was accomplished in this arm, the incision passing through the center of the pedicle graft. Figure 8 shows a comparison of recovery of sensation in the two grafts three hundred and seventy-eight days after operation.

Recovery of sensation in the pedicle graft is complete except in the immediate vicinity of the healed, surgically incised wound. Recovery of sensation in the split

thickness graft followed a peripheral pattern, and this is one of the few cases in which this occurred. Dorsal to line *B* the prick from the 4 Gm. algesimeter, light touch and temperature sensation are appreciated. Ventral to the dotted line the prick from the 14 Gm. algesimeter is identified. The unmarked portion is insensitive. The slower rate of recovery of sensation in the split thickness graft is obvious.

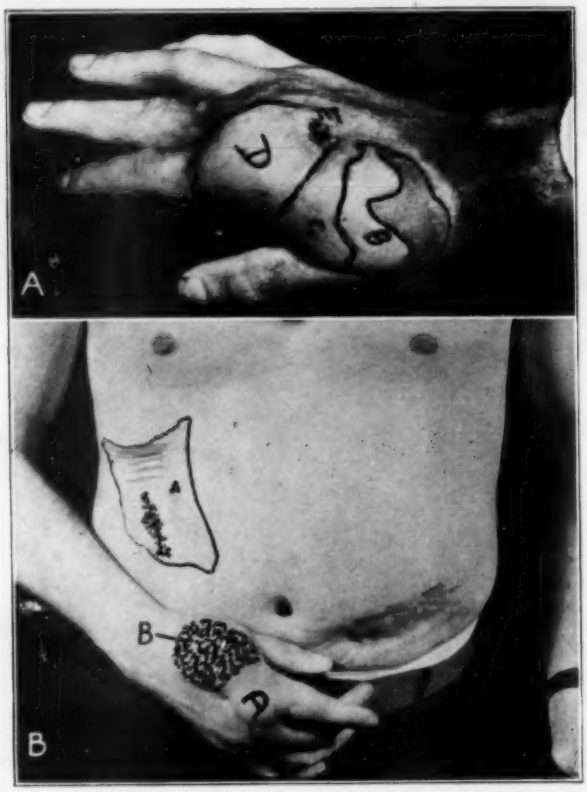


FIG. 9.—*A*, two pedicle grafts are seen. In the solid color the pressure from the 4 Gm. algesimeter and touch and temperature sensations are demonstrable. In region *B* the 14 Gm. algesimeter is identified as pinprick; in region *C* only the 34 Gm. algesimeter elicits a pain response. This graft is one hundred and fifty-five days old. Area *D* is completely insensitive and is the thirty-eight day old second pedicle graft with an area (*E*) of necrosis. *B*, in first pedicle graft *B* outlined with dots, three hundred and seventy-eight days old, sensation is essentially normal. Second pedicle graft *D*, two hundred and sixty-one days old, is devoid of sensation. Lack of recovery of sensation in second graft apparently is due to the ability of scar tissue of the suture line and of area of necrosis (*E*) to prevent ingrowth of sensory nerve fibers into the graft. Recovery of sensation in the split thickness graft applied to the donor site on the abdomen, two hundred and sixty-one days old, is incomplete.

The patient volunteered the statement that sensation in the pedicle graft was much better than that in the split thickness graft.

*Case* 3.—A pedicle graft was raised from the abdomen and transferred to the right hand to cover a defect created by a wound from a high explosive shell. The

distal portion of this graft sloughed and healed by secondary intention. The resultant adherent cicatrix was excised later and another pedicle graft from the abdomen transferred to the hand. The donor site of the original pedicle graft healed by secondary intention. That of the second was covered with a split thickness graft. Figure 9*A* shows both pedicle grafts one hundred and fifty-five days after the first operation and thirty-eight days after the second. In the solid area the pinprick from the 4 Gm. algesimeter is identified and touch and temperature sensations are present. In region *B* the prick from the 14 Gm. algesimeter is identified, and in region *C* that from the 34 Gm. algesimeter is identified. *D* is the second pedicle graft in which there is no evidence of recovery of sensation at this time. In region *E* of the second pedicle graft a small area of necrosis is seen. Figure 9 *B* shows the same two pedicles three hundred and seventy-eight days after operation. Sensation in the pedicle graft *B* is essentially the same as that in the surrounding skin. Pedicle graft *D* is completely anesthetic. Apparently the scar tissue of the suture line between the two grafts and the area of necrosis *E* is sufficient to block the ingress of nerve fibers. The patchy and markedly incomplete recovery of sen-

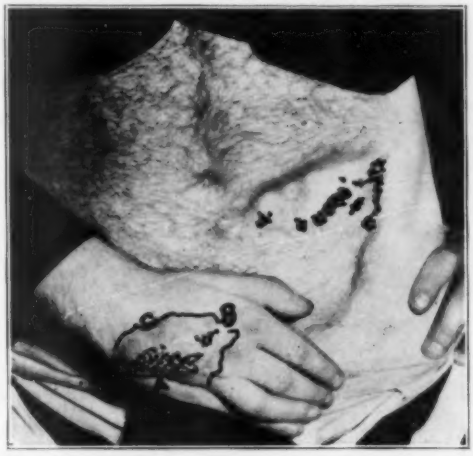

FIG. 10.—Depicts comparison of recovery of sensation in pedicle graft to the dorsum of the hand and in split thickness graft to the abdomen, each three hundred and seventy-six days old. Necrosis of the suture line occurred in the pedicle graft in region *C*, resulting in increase in local scar sufficient to block ingrowth of regional nerves. Recovery of sensation is seen in dotted areas *A* and *B*, in which regions touch and temperature sensations are recognized. Pressure sensation is present throughout. Recovery of sensation in split thickness graft has the characteristic patch pattern. In areas of recovery touch and temperature sensations are present. Unmarked regions are anesthetic.

sation in the split thickness graft of the abdomen again is visualized. Sweating of the skin of pedicle grafts is absent.

*Case* 4.—A pedicle graft was transferred from the abdomen to the dorsum of the right hand and a split thickness graft applied to the donor site of the pedicle. Necrosis of the suture line occurred on the radial side (*C*), which resulted in increase in the amount of scar tissue in this region. Figure 10 depicts the recovery of sensation in both grafts.

From the periphery of the ulnar side of the hand sensation has penetrated to about half of the graft. On the radial side the scar tissue secondary to necrosis of

the suture line has effectively blocked the ingress of nerve fibers except in a small region at the distal end (*B*). Touch and temperature sensations are present in the dotted region. The unmarked portions of the graft are devoid of sensation. Patches of sensation are present throughout most of the split thickness graft. In all these the pressure from the 4 Gm. algesimeter, light touch and temperature were identified. The regions without markings are devoid of sensation. As finer discrimination is present throughout the extent of each patch, it seems likely that recovery of sensation has reached the maximum.

*Case 5.*—A huge defect in the right forearm was covered with a pedicle graft from the right side of the abdomen and thorax, and at the same time the donor site was covered with a split thickness graft. Figure 11 shows the amount of sensation recovered in each type of graft one hundred and ninety-six days of operation. Sensation in the pedicle graft has begun to invade at the proximal end and is

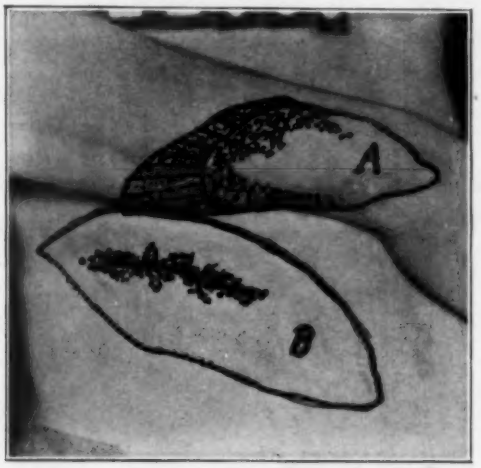


FIG. 11.—One hundred and ninety-six day old pedicle graft *A* to arm and split thickness graft *B* to abdomen. The characteristic pattern of recovery is depicted in pedicle graft *A* with a gradation from finer discrimination of touch and temperature sensation in the striped portion to sensitivity to pain only in the dotted region and absence of sensation in the unmarked area. A single, isolated elongated, centrally placed patch of sensation is present in the split thickness graft *B*. Finer discrimination is limited to the solid-colored area in the center of the patch.

extending distally in an orderly fashion. In the striped region sensations of pain, touch and temperature are present. In the dotted portion only pain is appreciated, and there is a complete absence of sensation in the unmarked region. In the huge split thickness graft recovery of sensation is limited to an elongated patch in the center. About the periphery of this patch, in the dotted region, pain sensation alone is present. In the central solid portion sensations of pain, touch and temperature are present. Elsewhere the graft is anesthetic.

The findings in the foregoing 5 cases are typical of our experience with the two types of skin grafts. The balance of evidence favors the idea that recovery of sensation in a pedicle graft results from ingrowth of nerve fibers from the surrounding tissue. Under favorable conditions of growth recovery of sensation of pain begins in three to six

months in the region of the proximal nerve supply and extends distally the course of growth of nerve fibers being parallel to the surface of the skin. The only contradictory finding to this conception is seen in figure 12.

*Case* 6.—The patient sustained a wound from a high explosive shell which left a defect in the tibia and the overlying soft tissue of approximately 1 7/8 by 1 1/2 inches (5 by 4 cm.). A pedicle graft was raised from the side of the calf and swung over the site of the defect. The base of the defect was composed of bare bone. Three hundred and five days after operation there was no evidence of recovery of sensation.

FIG. 12.—Pedicle graft three hundred and five days old transplanted to a base of bare bone. Despite normal sensation of the surrounding skin, there is no evidence of recovery of sensation.

Kredel and Evans reported similar findings in 3 cases.

As the surrounding skin has normal sensation it is difficult to explain the failure of the nerves to invade these grafts.

In cases in which there were split thickness grafts more than one year old there was no evidence of recovery of sympathetic innervation.

## SUMMARY

The findings in 187 cases in which split thickness grafts were used to cover defects are presented. These studies reveal that recovery of

sensation in split thickness grafts is incomplete and patchy. Sensation may be demonstrated in an occasional instance as early as the tenth postoperative day, but in the majority sensation first appears between the seventh and the ninth week postoperatively.

The ingress of nerves into a split thickness graft is from the underlying tissues as well as from the tissue about the periphery. Hence an intact nerve supply in the recipient area as well as about the periphery is essential to the recovery of sensation.

Scar tissue effectively blocks the ingress of nerves into split thickness grafts. Therefore recovery of sensation is not to be expected in a graft that is firmly adherent to its underlying base irrespective of whether it be muscle, fascia or bone.

By the use of an algesimeter which applies 14 Gm. of weight to a pinpoint, pain sensation can be elicited long before the light touch sensation from a wisp of cotton is appreciated; the probability exists that this is due to a comparison of unequivalent stimuli. When pain sensation was elicited by the use of an algesimeter which applied 4 Gm. of weight to a pinpoint, the light touch sensation from a wisp of cotton always was appreciated, which suggests that these are approximately equivalent stimuli.

## CONCLUSIONS

1. Recovery of sensation in split thickness skin grafts is incomplete and patchy, and the degree of fine sensation exhibited by pedicle skin grafts is rarely achieved.

2. The failure of split thickness grafts to recover sensation completely should be appreciated as a distinct disadvantage.

3. A study should be made of the recovery of sensation in every split thickness skin graft applied to a region likely to be exposed to trauma, and when this presents a hazard a pedicle skin flap should be substituted.

4. A recipient site with a good layer of subcutaneous fat and with an intact nerve supply is the most favorable for growth and recovery of sensation.

# TYROTHRICIN AS AN ANTIBIOTIC

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TYROTHRICIN was first discovered by Dubos[1] in 1939. He isolated an alcohol-soluble and water-insoluble substance from the autolyzed cultures of an anaerobic, motile, spore-forming bacillus of the soil which had been called Bacillus brevis. This was highly active and bactericidal against various gram-positive organisms, which include Staphylococcus, Stroptococcus and Diplococcus pneumoniae. Dubos named this substance gramicidin. However, further investigation by Dubos and Hotchkiss[2] proved that a second substance was also present. This substance had some degree of activity against gram-negative organisms and was named tyrocidine. Because of the two substances the name of the bactericidal extract was then changed to tyrothricin.

Further investigation indicated that tyrothricin contains approximately 85 per cent tyrocidine and 15 per cent gramicidin.[3] A single injection of O.1 mg. of tyrocidine administered intraperitoneally is sufficient to protect mice against 10,000 fatal doses of the pneumococcus.[4] This is, however, much less active than gramicidin, since the same protective effort could be obtained with 0.002 mg. of the latter substance. Tyrocidine is also much less toxic than gramicidin but has been shown to be extremely hemolytic. Concentrations of tyrocidine of 0.4 mg. have been strongly hemolytic against rabbit erythrocytes. No hemolytic effect was shown with gramicidin in dilutions as low as 0.02 Gm. Complete hemolysis took place after fifteen minutes of exposure to tyrocidine in the aforementioned concentrations, but there was no hemolysis after twenty-four hours of exposure to gramicidin. Therefore, it is evident that the hemolytic factor of tyrothricin is due almost solely to the tyrocidine content.

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From the Department of Surgery, University of Illinois College of Medicine. Aided by a grant from Sharp & Dohme, Inc., Philadelphia.

1. Dubos, R. J.: J. Exper. Med. **70**:1, 1939.
2. Hotchkiss, R. D., and Dubos, R. J.: J. Biol Chem. **136**:803, 1940.
3. Robinson, H., and Moliter, H.: J. Pharmacol. & Exper. Therap. **74**:75, 1942.
4. Dubos, R. J.: Ann. Int. Med. **13**:2025, 1940.

Tyrocidine is inhibited strongly by the presence of peptones and serums, and it has been shown that it has little if any activity in vivo. It does attribute some solubility and stability to the extract; therefore, separation of these two for practical purposes need not be done. It is thus apparent that almost all the activity in vivo is definitely due to the gramicidin content, and the best results should be obtained in the action against the gram-positive organisms.

Johnson[5] has shown that tyrothricin is capable of destroying the motility of Trichomonas microdentium, T. macrodentium, T. vincentii, T. buccalis, T. mucosum and a variety of vibrios and fusiform bacilli occurring in the mouth. Saliva has also been shown to be a factor slighly inhibiting the action of tyrothricin; the amount required for inhibiting the growth of all gram-positive organisms was found to be 0.6 mg. per cubic centimeter.

It has also been shown that tyrothricin has been found to possess some bactericidal activity against cultures of Leishmania tropica, Trypanosoma cruzi and lewisi as well as against T. vaginalis in vitro.[6]

Mixed cultures of gram-positive and gram-negative organisms will reduce the activity of tyrothricin in vivo.[7] This has been shown to be due to the cephalin and other certain related substances found in gram-negative organisms which are strongly inhibitory. In all clinical studies to date this statement has been verified, mediocre results being obtained in infections of the mixed flora type. Tyrothricin is both ineffective and nontoxic when given orally. The flora of the gastrointestinal tract is not changed.[3]

The chemical properties of tyrothricin show that it is insoluble in water and in blood serum and is impermeable to colloid membranes. It has also been shown to cause hemolysis of the red blood cells. Hemolysis has been shown to be due mostly to the tyrocidine content; however, the gramicidine element also has toxic qualities. Therefore, the intravenous use of tyrothricin is dangerous and also of no therapeutic value.

Tyrothricin suspension must come into actual contact with the bacteria before it can have its bactericidal effect.[8] Bacteria brought to the surface are killed almost instantaneously on contact with tyrothricin.[9]

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5. Johnson, F. G.: J. Am. Dent. A. **30**:1909, 1943.

6. Weinman, D.: Proc. Exper. Biol. & Med. **54**:38, 1943.

7. Rammelkamp, C. H.: Use of Tyrothricin in Treatment of Infections: Chemical Studies, War Med. **2**:830 (Sept.) 1942.

8. Bordley, J. E., and others: Ann. Otol., Rhin. & Laryng. **51**:936, 1942.

9. MacKee, G. M.; Sulzberger, M. B; Hermann, F., and Karp, F. L.: J. Invest. Dermat. **7**:175, 1946.

The toxicity of tyrothricin is high and is due mostly to the hemolytic tendencies which are attributed to tyrocidine.[10] The minimal lethal dose of tyrothricin for intravenous administration in dogs is approximately 0.4 mg. per kilogram.[11] The minimum lethal dose for mice is approximately 0.3 mg. per kilogram.[12] In animals dying of toxicity due to tyrothricin there are decisive changes in the liver, spleen, lungs, heart and kidneys.[11] Tyrothricin is used locally in concentrations of 0.1 to 0.5 mg. per cubic centimeter, a dose which is well tolerated by the tissues including the mucous membranes.[3]

Tyrothricin is available in alcoholic extracts, which are usually diluted with water to the proper concentration. Isotonic solution of sodium chloride should never be used because it precipitates the tyrothricin. Half a milligram of tyrothricin per cubic centimeter is isotonic. Concentrations higher than this may produce local irritation, with pain, discomfort, hyperemia and edema. Only fresh solutions should be used, and all solutions should be discarded within twenty-four hours. At the present time tyrothricin is also available in ointment form at various concentrations.

As one can see from the previous portions of the paper, the use of tyrothricin will have to be limited to topical application, and therefore it is associated with marked handicaps and limitations. Best results are expected in superficial infections and only in those which are readily accessible to tyrothricin by irrigation or by direct application since tyrothricin destroys only the bacteria with which it comes in direct contact. Tyrothricin kills bacteria on contact almost immediately in contrast to penicillin,[10] which takes a lot longer to attack the same organism locally. It also does not retard the healing of wounds and kills much faster than the sulfonamide compounds. Tyrothricin activity is not inhibited by the presence of serum or blood. Since the therapeutic activity is due mainly to the gramicidin content, best results are obtained in infections in which the gram-positive group notoriously predominate. When gram-negative organisms predominate, applications of tyrothricin are likely to be ineffective, and it is noticeable that the pseudomonas organism notoriously inhibits the action of the tyrothricin. Therefore, the indication for tyrothricin therapy would be based largely on the results of the bacteriologic examination of the flora of the lesion in question.

Favorable results have been observed in the treatment of a typical undermining ulcer of the skin of the Meleney type.[13] The patient

10. Heilman, D., and Herrell, W. E.: Proc. Soc. Exper. Biol. & Med. **46**:182, 1941. Rammelkamp, C. H., and Weinstein, L.: ibid. **48**:211, 1941.
11. MacLeod, C. M., and others: Proc. Soc. Exper. Biol. & Med. **43**:461, 1940.
12. Hotchkiss, R. D., and Dubos, R. J.: J. Biol. Chem. **132**:721, 1940.
13. Meleney, F.: Ann. Surg. **101**:997, 1935.

involved had been hospitalized on more than one occasion for at least six years with recurrence of the lesion. Tyrothricin therapy plus wide excision and skin graft healed the lesion completely in ninety days. Tyrothricin was also used in a case of severe bacterial gangrene of the skin which was also described initially by Meleney.[14] Tyrothricin kept down the secondary infection and held the areas under control until adequate surgical treatment, blood transfusions, high protein diet, meticulous nursing care and skin grafts could complete the cure. The patient left the hospital after about nine months of continued therapy, with approximately 45 per cent of the body surface denuded by the underlying type of infection. No toxicity was noted in either case. Infected wounds in which the organism is predominantly gram-positive respond favorably to tyrothricin therapy.

I also used tyrothricin intraperitoneally for experimental purposes in an attempt to show whether or not tyrothricin would be effective against (1) Clostridium welchii infection and (2) peritonitis due to perforation of the bowel. A careful control study using 400 white mice and 25 guinea pigs showed conclusively that tyrothricin will not protect an animal from peritonitis due to Cl. welchii or Escherichia coli. It is well known that tyrothricin is absorbed from the peritoneal cavity, since it has been shown that the drug protects animals against streptococcic or pneumococcic peritonitis.[4]

### CLINICAL STUDIES AND RESULTS

Granulating wounds in 10 patients being treated at the Illinois Research Hospital in preparation for skin grafts were treated locally with tyrothricin. Cultures of material from the wounds were made at frequent intervals; as noted by other observers, streptococci were eliminated rapidly. In 1 case the granulating area (resulting from a burn) measured approximately 40 per cent of the total surface; tyrothicin was applied every day over the total area for approximately one month, with no toxic effect.

Rankin[15] and others have shown tyrothricin to be beneficial in the treatment of ulcers of the leg. A small series of 15 patients with such lesions have been treated at Illinois Research Hospital by local application of tyrothricin. The cause of the lesion in 14 of the patients was thrombophlebitic; in 1 it was traumatic. All patients were given

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14. Meleney, F.: Surg., Gynec. & Obst. **56**:847, 1933.

15. Rankin, L. N.: Am. J. Surg. **65**:391, 1944. Herrell, W. E., and Heilman, D.: J. Clin. Investigation **20**:583, 1941. Crowe, S. J., and others: Ann. Otol., Rhin. & Laryng. **52**:541, 1943. Bellows, J. G.: Chemotherapy in Ophthalmology, Arch. Ophth. **29**:888 (June) 1943. Heath, P.: Chemotherapy in Ophthalmology, J. A. M. A. **124**:152 (Jan.) 1944.

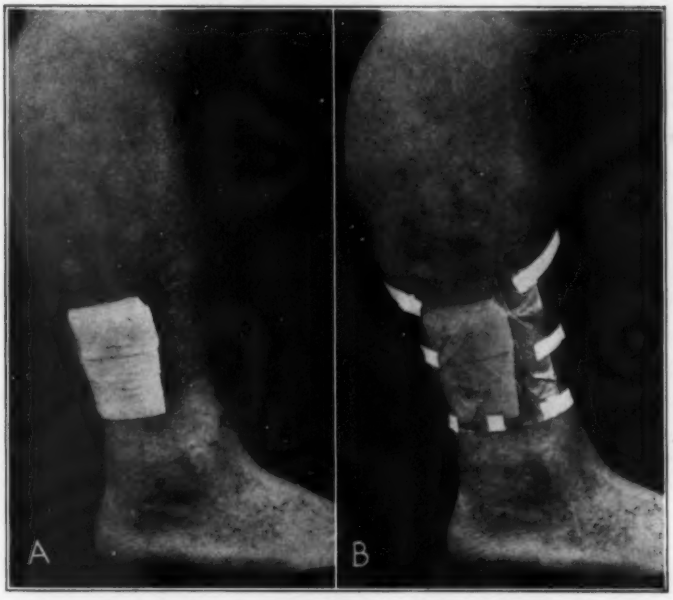


FIG. 1.—Dressing technic in tyrothricin therapy. *A*, a sterile dressing is placed over the ulcer and saturated with tyrothricin; *B*, wax paper is placed over the dressing to prevent drying.

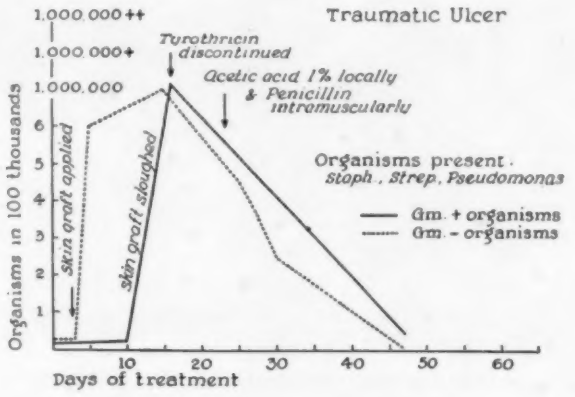


FIG. 2.—This chart reveals the inhibitory effect of the gram-negative organisms on tyrothricin. The count of the gram-negative organisms rose sharply on the fourth day, reaching its maximum on the ninth day. This invasion of gram-negative organisms presumably inhibited the action of tyrothricin to such an extent that gram-positive organisms invaded the wound and destroyed the graft. Discontinuance of the use of tyrothricin and treatment with acetic acid (locally) and penicillin (intramuscularly) resulted in control of the infection. Another graft applied later was successful.

ambulatory treatment. The ulcers were of the chronic type; all of them had been present for at least one year. Other types of therapy had been used but had failed. The patients were followed twice a week in the outpatient clinic, at which time complete bacteriologic studies were made. The dressings were changed and new ones saturated with tyrothricin (0.5 mg. per cubic centimeter of water) applied; wax paper was placed over the dressing to prevent drying (fig. 1). Patients were instructed to change the dressings daily at home by the same technic.

Naturally, a satisfactory dressing technic was difficult to maintain. Results of bacterial studies were thereby jeopardized. Among

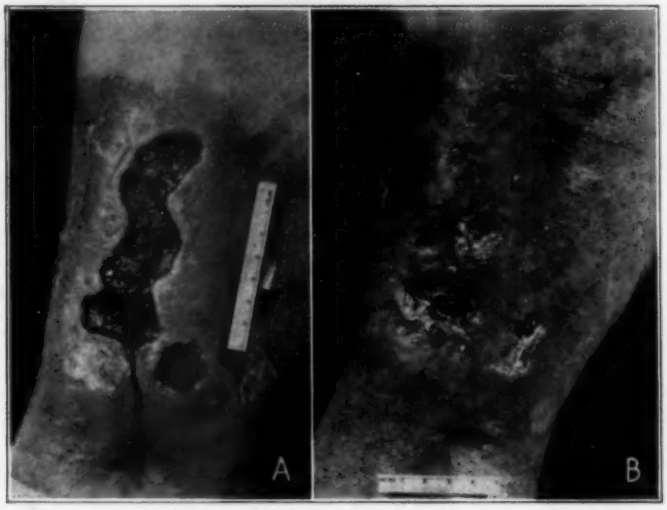


FIG. 3.—The postphlebitic ulcer shown in *A* had resisted all types of therapy for nine years. After several weeks of treatment with tyrothricin the ulcer began to heal as shown in *B*. After one hundred and five days of therapy, it was completely healed.

the series of 15 patients with ulcers on the leg healing took place in 9 within four to twelve weeks although recurrence developed in 2.

These results are not outstanding, but it can be said that local therapy with tyrothricin was distinctly beneficial in half of the cases. It was noted also that when pseudomonas bacilli were present in large numbers the tyrothricin was inhibited and healing was retarded (fig. 2). To counteract pseudomonas contamination, acetic acid dressings were applied until the infection was under control. In a patient with bilateral ulcers one side was treated with tyrothricin solution and the other with boric acid solution. In spite of the fact that tyrothricin was used on the larger ulcer, the results showed that

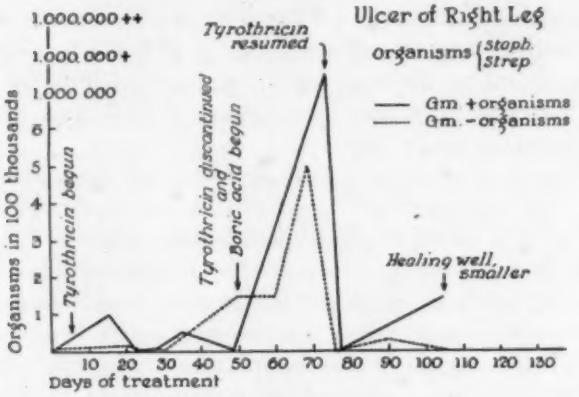


FIG. 4.—Graph showing bacterial count of ulcer illustrated in figure 5; the ulcer was treated first with tyrothricin, later with boric acid (unsuccessful) and finally with tyrothricin (see figure 5*B*).

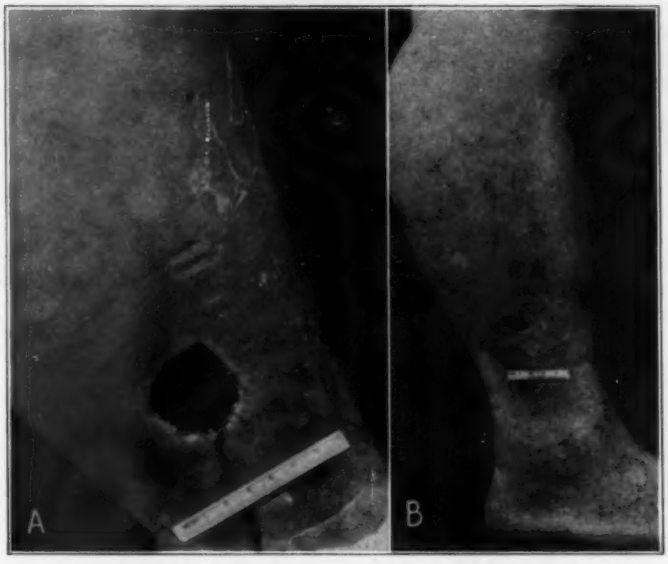


FIG. 5.—*A*, appearance of ulcer before treatment. Tyrothricin locally was used for the first forty-five days, and the ulcer was healing satisfactorily; its use was discontinued on the forty-fifth day, and boric acid solution was applied. Immediately the ulcer changed from a clean healing ulcer to one which became grossly infected. The cultures showed that gram-positive organisms were out of control and responsible for the infection. Tyrothricin therapy was resumed on the seventieth day, and the ulcer again began to heal; the gram-positive organisms were practically eliminated from the flora of the ulcer.

*B*, appearance of ulcer several weeks after resumption of treatment with tyrothricin.

the gram-positive bacterial flora was immensely reduced on this side and that healing was much faster (figs. 3 and 4). Subsequently, tyrothricin was used on the ulcer, which was treated initially with boric acid; the bacterial flora was immediately altered, and healing progressed more satisfactorily (fig. 5).

In the lesions responding poorly or not at all the bacterial counts remained high. Although it is possible that inadequate care at home may have been a factor in these poor results, there is of course no proof. The fact is also appreciated that organisms may have been resistent to tyrothricin. In 1 patient healing took place when succinylsulfathiozole ointment was substituted for tyrothricin therapy.

Causes of failures with the use of tyrothricin may be listed as follows: (1) infection composed of gram-negative organisms; (2) mixed flora, especially when the pseudomona group predominates; (3) inability of the drug to come in direct contact with the organism; (4) strain of bacteria resistant to the drug; (5) insufficient dosage of tyrothricin, and (6) use of old solution.

## CONCLUSIONS

From a study of the literature and from the results of clinical and experimental work at Illinois Research and Educational Hospital, the following statement may be made:

1. Tyrothricin is an antibiotic which is exceedingly effective and bactericidal against organisms of the gram-positive group.
2. Tyrothricin is extremely toxic and hemolytic; the parenteral route is dangerous.
3. Tyrothricin is markedly inhibited by the pseudomonas organism and by infections of the mixed flora type.
4. Tyrothricin should be used only topically and against organisms of the gram-positive variety.
5. Tyrothricin kills bacteria on direct contact within a short time; it is superior to penicillin or the sulfonamide compounds used locally.
6. Tyrothricin is absorbed from the peritoneal cavity and protects animals against streptococcic and pneumococic peritonitis but has no effect on peritonitis due to Escherichia coli or Clostridium welchii.
7. Tyrothricin has been used effectively in the treatment of chronic empyemas which are secondarily contaminated with streptococci.

8. Tyrothricin has been shown to be of value in several clinical conditions, among which are: (*a*) infected wounds in which the organism is predominantly of the gram-positive group, (*b*) thrombophlebitic ulcer, (*c*) sinusitis, (*d*) mastoiditis, (*e*) certain ophthalmic infections and (*f*) dental abscesses.

9. As yet no toxic reactions to the topical use of tyrothricin have been reported.

10. Since tyrothricin can be used only topically, its limitations are considerable, but when compared to other antibiotics for local therapy it is one of the most effective agents available.

# MANAGEMENT OF THE PARALYZED BLADDER

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PLANS FOR INSTITUTING the best possible type of treatment for patients with injuries of the spinal cord and their complications can be ideally developed in centers with large wards for paraplegic patients. Such centers can be found at several army general hospitals or at numerous veterans administration hospitals in the United States. In the institutions to which these patients are now being sent for definitive treatment there exists an excellent opportunity to study injuries of the spinal cord as well as to observe the results and the merits of the various accepted technics of management.

## THE PROBLEM

The patient is at first completely dependent on nursing care. On admission to the hospital he is confined to bed. He is paralyzed from his hips down. He may have no control of his rectal and urinary sphincters; he may have retention of urine and he may have several large decubitus ulcers, most commonly over the sacrum and hips. He may have renal or bladder calculi and urinary infection; he may be weak and undernourished, and his legs may be atrophied or they may be spastic and drawn up to the abdomen.

For such patients there exist numerous associated problems beside those presented by the genitourinary system. This paper, however, will concern itself chiefly with the management of the associated urologic conditions. One has only to see a full ward of such patients to realize the difficult technical problems involved and why a most extensive hospital program is necessitated (fig. 1).

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### DRAINAGE OF THE BLADDER

The patients to be discussed were admitted to the hospital with many different types of bladder drainage, i.e., suprapubic, urethral, automatic and semiautomatic. Usually in forward areas a suprapubic cystostomy was done within a few days after injury to avoid the possibility of a ruptured bladder during the soldier's quick and possibly rough evacuation to the rear areas. A suprapubic catheter was cared for more easily than a urethral catheter and eliminated the necessity for periodic catheterization when specialized care was not available.

FIG. 1.—Arrangement of bed and irrigation system in use in our cases, with drainage jug attached to the bed to prevent tipping and spilling and aluminum bedframe with trapeze arrangement which allows the patient to assist himself on the bedpan and to exercise the upper parts of the body.

In most instances the cystostomy openings that were seen on the patients' admission were placed correctly and functioned well. The few that have caused difficulty have been unsatisfactory for the following reasons:

1. Insertion of the catheter too low in relation to the bladder and the symphysis pubis causes several disagreeable results. Not only does the end of the mushroom catheter rest against the trigone and produce frequent spasms of the bladder and occasional fibrosis of

the bladder neck but the pressure of the suprapubic catheter against the symphysis pubis may cause occasional sloughing and infection, with the added danger of involvement of the bone. It has been my observation that even though sensation is frequently absent below the lesion the removal of a catheter that rests on the trigone will cause immediate relief to the patient.

2. Leaving a space between the bladder and the abdominal wall at the time of the original cystostomy produces a potentially infected area. This makes each reinsertion of the catheter difficult and sometimes impossible (fig. 2).

3. The loose fit of the catheter in the suprapubic tissues allows for urinary drainage out along the sides. This may be due to postopera-

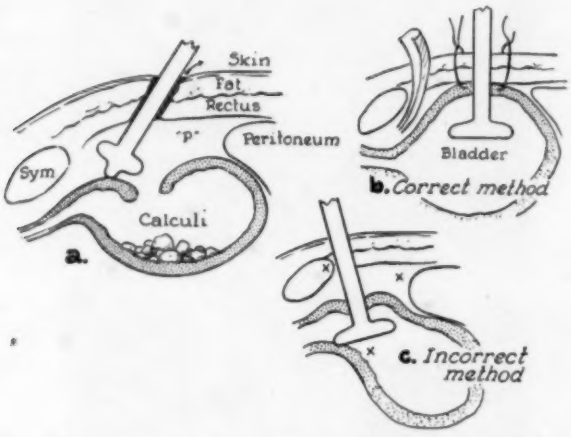


FIG. 2.— *a*, diagram of situation encountered in case 8 wherein extravesical pocket of urine, *P*, formed because of lack of proper bladder support. Healing was delayed, reinsertion of the catheter was difficult and there was leakage. *b*, the right method; the mushroom catheter is inserted in the upper aspect of the bladder away from the trigone and the symphyisis; the bladder wall is suspended and the drain is in low. *c*, the wrong method; the catheter is against the symphysis and the trigone, and the bladder has dropped.

tive slough of the tissues from too tight sutures, infection or insufficient fascial approximation.

These errors can be avoided in the following ways: First the middle or upper aspects of the bladder should be opened even though it may be necessary to make a low incision for the purpose of identification. By insuring some approximation of the bladder to the rectus muscles and the fascia the second error can be avoided. This can be done either with mattress sutures (as in fig. 3), in which case the original stay sutures for lifting the bladder are placed through the rectus muscle and tied as a supporting mattress suture with only moderate tension, or by the procedure that I have learned from Dr.

Robert Herbst (fig. 3*B*), namely, the use of a large retention suture going through the skin, fascia and muscle and catching the edge of the bladder wall. This is a simple procedure and one that works. A third method to insure good suprapubic drainage is to drain the anterior bladder space from the lower aspect of the incision and separately from the mushroom catheter. This allows any infection which may be present to drain from the lower end of the incision.

The previous theory that there should be absolute avoidance of urethral catheterization is no longer too seriously accepted by most urologists who have had to handle paraplegic patients during World War II[1]. It has been observed by my colleagues and me that patients with urethral drainage do just as well as those with suprapubic drainage if properly cared for. The danger of any possible trouble

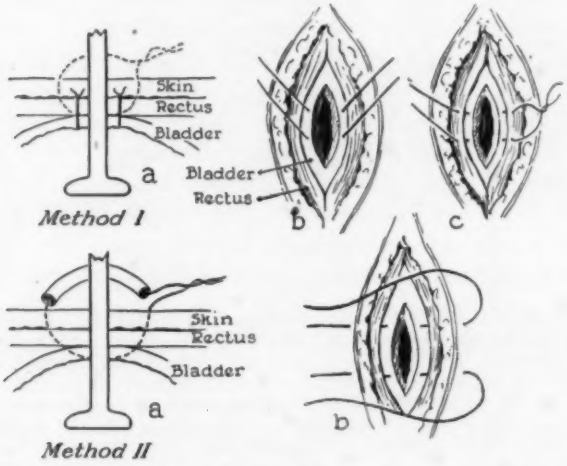


FIG. 3.—*a*, one method of suspending the bladder by using the original stay sutures through the rectus muscles. *b*, another means of doing the same thing by two through and through sutures, each of which catches part of the bladder wall.

from urethral drainage is greater than that from suprapubic drainage if both are neglected for any length of time. If properly irrigated, cleaned and changed at frequent intervals, the urethral catheters sometimes do better than the suprapubic catheters, especially in the matter of keeping the patient in a drier and more comfortable condition and also ambulant. Especially is this true if the suprapubic catheter had not been placed satisfactorily originally. Suprepubic cystostomies have been done in our cases only for the removal of large stones in the bladder. None have been performed so far for permanent drainage.

1. Lewis, L. G.: Treatment of Bladder Disfunction After Neurologic Trauma, J. Urol. 54:284-295 (Sept.) 1945.

The patients begin their treatment in the status in which they arrive; suprapubic drainage is maintained for those in whom automatic bladder fails to develop after repeated trials at spontaneous urination. We try to discover the ability for spontaneous urination as soon as possible. Patients are encouraged to urinate without any type of catheter as soon as it is compatible with their condition and comfort.

### THE AUTOMATIC BLADDER

I do not believe that automaticity can be hurried much, but by periodic lavage and dilation the bladder can be kept clean and elastic so that if automatic urination comes about the bladder will have retained its tone and capacity. The patients under discussion were sent to our hospital from elsewhere, so that no statement can be made

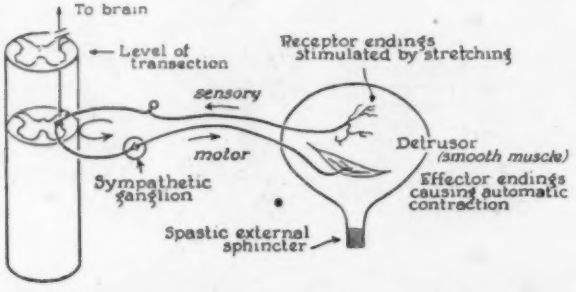


FIG. 4.—Automatic bladder in simple diagram as reflex arc (modified after that of Nash). Receptor endings in the bladder wall are stimulated during the stretching of a full bladder. The impulse is detoured through the reflex arc (not being able to reach the higher centers because of cord injury), then through the sympathetic ganglion to motor effector endings, causing an automatic contraction. This reflex arc usually comes into play several months after the initial injury. The bladder voids by overflow incontinence if not catheterized up to this period.

as to whether automatic emptying of the bladder would have developed sooner or not. All that can be said is that they were given a trial at urination as soon as they came. If they expelled urine either by automatic reflex or by abdominal pressure, with only little residual urine, catheter drainage was discontinued immediately. Urination around the catheter often gives a clue to the beginning of automaticity. The term automatic bladder refers to those bladders that either empty spontaneously and without volition at periodic intervals, usually one to three hours, or that empty almost completely by the patients' voluntary abdominal pressure, which may or may not be helped by manual expression. The latter are not true automatic bladders, but the end result is the same, namely, emptying of the bladder without a catheter by the patient himself. Many patients who have true automatic bladders can cause automatic urination by merely stimulating their ab-

domen by touch[2] (fig. 4). Best and Taylor's[3] description of an automatic bladder and of the effects of section of the spinal cord on micturition is as follows:

> Destruction of the sacral nerves or of the spinal centers will interrupt not only motor impulses to the bladder, but also the afferent impulses traveling by the pelvices and pudendals. The bladder is then completely isolated from central nervous control; but, after a period of retention of urine with overflow it expells its contents automatically . . . . Probably in such and other instances in which motor impulses from the central nervous system have been interrupted, local reflex arcs through ganglion cells in the vesical plexus or bladder wall are responsible for the automatic action The latter is only a makeshift for the normal micturition reflex since the bladder is not completely emptied but always retains a part of its contents (residual urine).

The aim is the development of an automatic bladder or a situation in which a catheter is not used. This of course will not be possible in all cases. However, it must be decided when the patient is ready for trial urination. Clinically, this would be when the bladder is able to contract and to expel the urine at periodic intervals without a catheter. We have found that when the pressure rises to over 35 mm. of mercury after the bladder has been filled with 100 or 150 cc. of fluid this is in the most cases indicative of a bladder able to empty itself (fig. 8). There are exceptions to this rule, of course, which occur because of extremely spastic sphincters. We have several patients now in whom the pressure is satisfactory but who still need retention catheters for residual urine because of a spastic sphincter. Evidence seems to point to the fact that automaticity develops as the tone of the spastic external sphincter decreases. For example, bilateral injection of procaine hydrochloride into the third sacral nerves often produces automatic urination immediately in patients having retention because of spastic sphincters; retention of urine recurs as the anesthetic wears off.[3a]

Our findings do not conform with the belief held by some urologists that if automaticity does not set in within four to five months a permanent suprapubic catheter should be inserted. We have several patients with lesions both high and low in the spinal cord from whom we have removed such "permanent" suprapubic catheters and who have been able to do without them. In some the bladders are not truly automatic, but the terminology is of no importance. We believe that if the patient can pass his urine without a catheter, whether by

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2. Nash.: Surgical Physiology, ed. 1, Springfield, Ill., Charles C Thomas, Publisher, 1942, p. 421.

3. Best, C. H., and Taylor, N. B.: The Physiological Basis of Medical Practice: A University of Toronto Text in Applied Psychology, ed. 2, Williams & Wilkins Company, Baltimore, 1939, pp. 670 and 1412.

3a. Personal communication to the author by Dr. Charles Mrazek, Vaughn Paraplegic Center, Hines, Ill.

automatic reflex or by contraction of the abdominal muscles and by manual expression, the desired end has been achieved.

### SYSTEM OF IRRIGATION OF THE BLADDER

The bladder irrigating system which we use is one that was originally developed for use in transurethral operations and for suprapubic prostatectomies to insure a frequent and foolproof method of irrigation. It is applied unusually well in the treatment of the paralyzed bladder. The bladder-irrigating system to be described here has been in use now for over three years in the management of the paralyzed bladder and has well withstood the trial of time (fig. 5*A*).

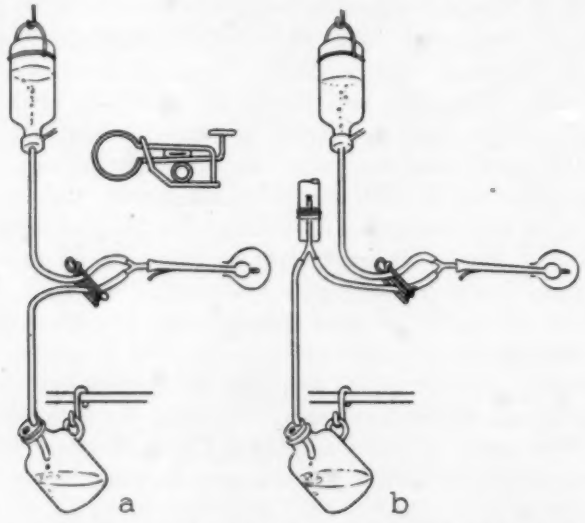


FIG. 5.—*a*, diagram of the usual drainage system used for most of our patients for dilation and lavage, by means of which they are taught to dilate their own bladders with the two way clamp. *b*, the same system with an elevated drainage tube for producing a constant, mild dilation of the bladder along with the other and more adequate periodic dilations. This is of occasional value for small, contracted, infected bladders.

*A* of figure 5 shows the closed system of irrigation used in almost all cases of spinal cord paralysis of the bladder. It is used for both urethral and suprapubic catheters before automaticity sets in. It is used to promote the periodic and frequent dilation and lavage of the paralyzed bladders and to encourage development of bladder tone so necessary for complete emptying.

The patient can irrigate his bladder six to eight times daily to a maximum degree by the manually controlled two way clamp[4] (fig.

4. Baumrucker, G. O.: Double Acting Clamp to Facilitate Bladder Irrigation, J. Urol. **47**:741-745 (May) 1942.

6*B*). This system also works well for hypotonic or flaccid bladders or for bladders with low pressures. A dependent type of drainage, as described here, with no constant pressure or residual effect along with periodic and frequent irrigations will handle such bladders more satisfactorily because they will then empty almost to completion by the siphonage method (fig. 6*A*).

*B* of figure 5 shows a closed system of irrigation occasionally used for small and extremely spastic contracted bladders in which a mildly

FIG. 6.—*A*, close-up of system *A* in figure 5. This arrangement is used in the majority of cases for periodic dilation of the bladder with either suprapubic or urethral catheters. The two way clamp is easily accessible for control by the patient himself. *B*, close-up of the two way clamp used to facilitate irrigations of the bladder. Photograph shows simple finger control which allows fluid to flow into the bladder and at the same time stops outflow from the bladder. Releasing the fingers, of course, allows the fluid to flow from the bladder by itself.

increased pressure is attained by elevating the drainage tube to or slightly above the level of the bladder. This is found desirable for cases in which a simple cystostomy tube has been present for some time, with an open system of drainage, and in which considerable contraction of the bladder has occurred around the indwelling mushroom catheter. I refer to cases in which automaticity has not yet set in. After the bladders become automatic no form of irrigation is used

except possibly a weekly or biweekly catheterization and irrigation for determining the amount of residual urine or the pressure in the bladder. Isotonic solution of sodium chloride has been used as an irrigating medium in most cases because of its safety.

### TIDAL IRRIGATION VERSUS A MANUALLY CONTROLLED SYSTEM OF IRRIGATION

The subject of "tidal" irrigation is discussed here in the hope of removing some of the aura of mysticism that surrounds it. There seems to be a fairly well rooted idea among medical men in general that treatment of the paralyzed bladder is tidal irrigation. The question is not one of whether to use tidal irrigation or some other type of closed system of irrigation but one of deciding what should be done in each individual case to promote early automatic function. The interest is in obviating the necessity for a catheter. It must be decided what problems are to be overcome. There are several, and each case presents its own; hence it is difficult to give directives to cover all cases of paraplegia. In the first place, the aim may be to combat an infected bladder or to prevent an infection and an ascending pyelonephritis. Secondly, it may be acute retention of urine and a subsequent large, flaccid and distended bladder which must be corrected. In the third place, the aim may be to combat involuntary and continuous dribbling of urine. Some patients have no residual urine but are continually losing urine because of poor sphincters (control here, of course, is important in successfully healing bedsores). Fourthly, the aim may be to prevent the formation of a small, fibrotic, contracted bladder such as results from a long period of "open" suprapubic drainage.

An attempt must be made to prevent the mistakes of World War I, in which, as has been shown by other writers on the subject, the danger from the open system of suprapubic drainage was the development of a small, infected, fibrotic bladder. Another danger when catheterization was not practiced was an overflow incontinence. This usually led to a large, flaccid, overflowing bladder, which in turn would become fixed in the distended state. Both the small contracted bladder and the large flaccid bladder would then lose forever their ability to contract or to become elastic or eventually automatic. Therefore, it seems that the problem would be solved by the insertion of a comfortable Foley catheter of small caliber, with some sort of an arrangement for frequent irrigations. This would counteract infection, preclude retention of urine and involuntary dribbling, keep the patient dry and prevent, by means of continual drainage, the formation of a large flaccid bladder. The frequent dilation would also

prevent the formation of a small contracted bladder. The problem of what type of irrigating system to use usually depends on the preference of the urologist in charge. Both of the systems discussed here have advantages and disadvantages.

"Tidal" drainage is a good system of irrigation of the bladder and solves most of the problems fairly satisfactorily[5]. It works according to several different principles. It may be a continuous Murphy drip appended to a closed system of irrigation which finally fills the bladder to the contracting point; the bladder then spills the urine through an elevated drainage tube, similar to system *B* of figure 5, down to a bedside jug. It may work through a small siphon bottle below the Murphy drip, whereby the bottle empties periodically through siphonage and fills the bladder, which then empties through a raised drainage tube. The value of any tidal type of irrigation for the large flaccid bladder is questionable because in actual practice it often leaves constant residual urine. Its efficiency depends on some tone being present in the paralyzed bladder to initiate emptying after every tidal filling. Many of the bladders are too weak to expel urine after filling, and hence the bladder sometimes remains partially filled. Its value for the small contracted bladder is satisfactory. However, if the bladder is considerably spastic the tidal mechanism may have a tendency to trip too frequently, and the bladder will therefore not be adequately distended. Tidal irrigation accomplishes its purpose provided there is good supervision and organization to supply the large volumes and frequent changes of irrigating fluid necessary. One drawback of the system as it is normally used with the Murphy drip is that it cuts down the patients' activity because of the slow dripping process necessary to fill the bladder.

The system described here, however, is simple and foolproof. The bladder cannot be overdistended accidentally because by simply dropping the clamp the intake is shut off, the outflow released and the bladder allowed to empty.[6] True, the success of the closed system with the two way clamp and the finger control depends on the individual patient or on the ward personnel. But we have found that if the system is originally explained to the patient and he is told what his problem is and what we are trying to accomplish there is little trouble getting a conscientious response.

In Technical Bulletin 162 published by the Dar Department in May 1945[7], in which there is described a complete regimen for the

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5. Munro, D. and Hahn, J.: Tidal Drainage of the Urinary Bladder, New England J. Med. **212**:299-239, (Feb. 7) 1935.

6. The double-acting clamp described can be procured from V. Mueller and Company, Chicago, Ill.

*(Footnotes continued on next page)*

management of the paralyzed patient, preference is expressd for a manually controlled system instead of the tidal irrigating system. Our preference is based on the simplicity and ease of operation of the former in contrast to the mechanical intricacies of tidal irrigation. The addition of the two way clamp to any manually controlled system further increases its simplicity and value. The results that we have obtained with this type of irrigation system have been most

TABLE 1.—*Relation Between Level of Lesion and Function of the Bladder.*

| | High Lesions (C6 to D12) (26 Cases) | Low Lesions (L1 to L5) (12 Cases) |
|---|---|---|
| Average amount of residual urine | 60 cc. (with 4 other patients needing a retention catheter) | 33 cc. (with 2 other patients needing a retention catheter) |
| Average voiding pressure | 60 mm. Hg | 84 mm. Hg. |
| Average capacity | 220 cc. | 280 cc. |

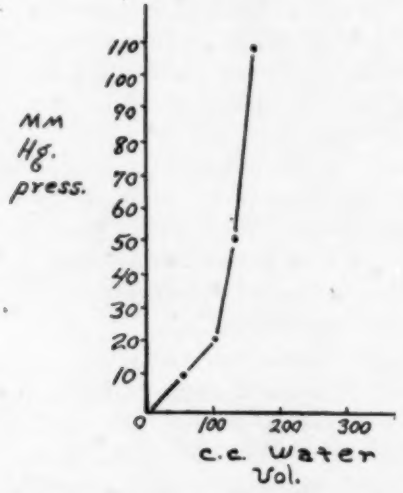


FIG. 7.—A composite curve of the initial cystometer tracings of these bladders shows a hypertonic type of curve. There is an average capacity of 150 cc., the usual rest pressure being fom 20 to 30 mm. of mercury; the maximum pressure varies anywhere from 30 to 120 mm. of mercury, dependent on the tone of the bladder and abdominal muscles.

satisfactory. I feel, however, that a tidal system may have definite advantages in the handling of cases of quadriplegia, in which, because of the paralysis of the upper extremities, it is impossible for the

7. Convalescent Care and Rehabilitation of Patients with Spinal Cord Injuries, United States War Department, Technical Bulletin (TB Med. 162), Washington, D. C., Government Printing Office, May 1945.

patients to irrigate their bladders. Since these patients are confined to bed and ambulation is not a problem, a functioning tidal lavage system controls drainage of the bladder adequately.

### ANALYSES OF RESULTS

1. *Relation Between Level of Lesion and Function of the Bladder.*—Table 1 shows the relation between the level of the lesion and the function of the bladder. It seems that the better abdominal tone of the lower lesions, by acting as a supplementary emptying force on the bladder, makes up for the poorer automaticity characteristic of these lower lesions. This results in a higher voiding pressure and in less residual urine (fig. 7).

II. *Cystometric Pressure and Automaticity*[8].—Knowledge of the pressure and volume in the bladder is important in the treatment and prognosis of each patient[9]. We have, however, given up taking full cystometric tracings. We prefer individual readings. A complete curve is of no therapeutic value or clinical interest in the treatment of these conditions. What needs to be discovered is the relationship of the abdominal pressure to the pressure in the bladder with a moderate amount of residual urine. One hundred and fifty cubic centimeters of fluid in the bladder is used for all readings, and all results are for one definite value. With this set of conditions we have found that almost all bladders that cannot produce a rise of over 35 to 40 mm. of mercury with abdominal pressure will not empty satisfactorily without a catheter[10] (fig. 8*A*). Because of the existing increased tone of the external sphincter associated with a paralyzed detrusor muscle in many cases of paralysis, the intracystic pressure must be greater than that of the normal bladder before urine can be forced out. Patients in whom there is an increase of over 40 mm. (usually 70 to 100 mm.) are ready for trial without a catheter if catheter drainage is still being used. These have, for the most part, responded well to urination without the use of a catheter; the exceptions are mentioned in the paragraph discussing "factors retarding the development of an automatic bladder." Some of these factors are fibrosis of the neck of the bladder, bars and extremely spastic sphincters.

In case 13 we found a cystometric pressure of only 20 mm. and residual urine amounting to 250 cc. after all trials at urination. The suprapubic catheter was removed, and a urethral catheter was installed. After a six month gymnastic program, cystometric pressure

8. The 120 mm. Pressure gage used has been made up for me by the United States Gauge company, of Chicago and New York.

9. Mullenix, R. B., and Major, M. C.: Cystometry in the Study of Traumatic Neurogenic Bladder, J. Urol. **55**:470-481 (May) 1946.

10. Baumrucker, G. O.: A New Instrument—The Fluid Volume Gauge: Its Use in Cystometry, J. Urol. **42**:629-636 (Oct.) 1939.

showed an increase to 50 mm. which was due, we feel, to the increase in the development of abdominal muscles and to increased muscle tone. Immediately after the removal of the catheter, the patient was able to urinate every thirty minutes, with 100 to 150 cc. of residual urine. Moreover, four months after removal of the catheter he was

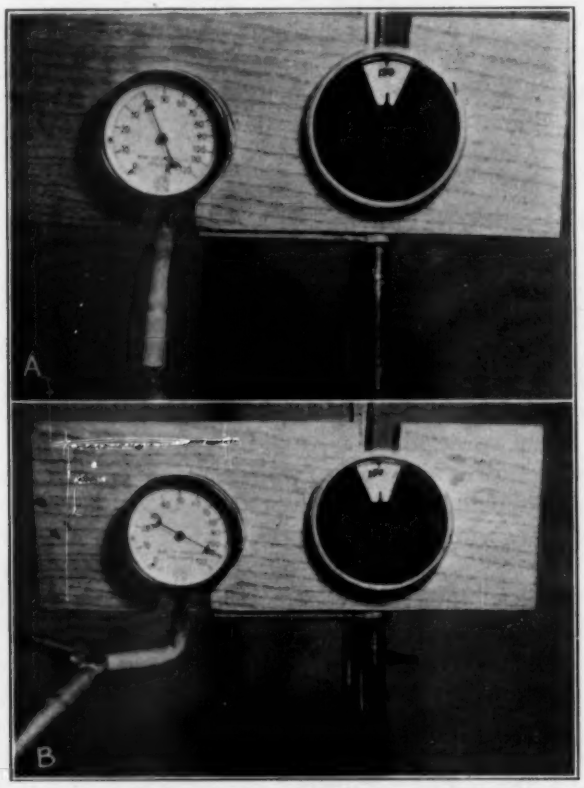


FIG. 8.—The cystometric equipment used is one that has two gages for simultaneous readings of both the pressure and the volume in the bladder (footnote 4). *A*, shows the initial pressure and volume just before the catheter was removed for trial urination (case 13.) A pressure of only 40 mm. of mercury was produced with manual expression and abdominal contraction. *B*, shows a pressure reading of 120 mm. of mercury being recorded during a sudden involuntary spasm of mass reflex. The previous maximum voluntary abdominal pressure was 50 mm. (case 24).

able to retain his urine for two hours and had a residual amount of only 50 cc.

III. *Management of Patients with Spastic Paraplegia.*—Anterior rhizotomy or section of the nerve roots has been done for pain, muscle spasm and dorsiflexion of the lower extremities. Interruption of the lower motor neuron reflex below the lesion of the spinal cord in this way produces a flaccid paralysis[11]. This makes the patient definitely

*(Footnotes on next page)*

easier to handle and allows for the success of graft operations over the trochanter. This procedure has also decreased the spasms of the bladder and hence the frequency of involuntary urination (in the 2 patients on whom it has been performed) from every half hour to every three hours.

Cases 3, 24, 25 and 33 show the effect of "mass reflex" on the pressure in the bladder. In all 4 cases contraction or spasm of the body occurred during the estimation of pressures, probably elicited by passage of the catheter (fig. 8*B*). This was accompanied with involuntary urination, sudden increase in intracystic pressure to 120 mm. of mercury and "cold" perspiration. This reflex occurs in conditions in which reflex activity predominates and follows the recovery of the spinal centers released from higher control.

IV. *The Value of Resection of the Neck of the Bladder (Causes Retarding the Development of an Automatic Bladder.)*—We have found that, besides atonicity of the bladder, retention can be due to two other factors: (1) a mechanical factor, such as fibrosis of the neck of the bladder or median bar obstruction and (2) an extremely spastic external sphincter. The latter condition is a natural sequela to a complete section of the spinal cord, according to Best and Taylor.

We have not as yet decided to produce wilfully an incontinence by cutting the external sphincter in patients who have retention of urine. We believe that the patient is happier and an easier nursing problem when he is using a catheter for retention than when he is incontinent and not using a catheter. A transurethral operation on the paralyzed bladder has a role, though a limited one[12]. I have considered performing resection of the bladder neck only when there was something to resect, that is, when there was a mechanical obstruction such as fibrosis of the neck of the bladder or obstruction from the median bar of the prostate. If present, such an obstruction would hide the signs of an automatic bladder indefinitely. This points out the value of cystoscopy for paralyzed bladders which have not shown signs of developing automaticity within a reasonable time after the initial injury.

All bladders that have high amounts of residual urine and show inability to void automatically do not necessarily need resection of the neck, nor will they be benefited by such a procedure. There will be some bladders which will remain flaccid, have no tone and show a low cystometric pressure, sometimes permanently. They will probably never empty satisfactorily without a catheter, especially if there is an associated weak abdominal muscle.

11. Munro, D.: Rehabilitation of the Patient Paralyzed Below the Waist, New England J. Med. **233**:453-461, (Oct. 18) 1945.

12. Emmett, J. L.: Transurethral Resection in the Treatment of True and Pseudo Cord Bladder, J. Urol. **53**:545-564 (April) 1945.

This brings up the value of the second diagnostic aid in determining indications for resection, namely, cystometry. If the pressure in the bladder is low, as for instance below 25 or 30 mm. of mercury, it is doubtful whether it will be sufficient to cause urination. The result of resection in this circumstance would be less remarkable than in one in which there was good voiding pressure.

The ideal situation for resection is one such as is depicted in figure 9. Cystoscopic examination showed a definite fibrosis of the neck of the bladder; this was tight to the tip of the little finger as palpated through the cystostomy opening at the time calculi were removed. After the suprapubic fistula was healed the pressure in the bladder was 80 mm. of mercury. Yet the patient was unable to urinate for six months after closure of the suprapubic fistula and needed an in-

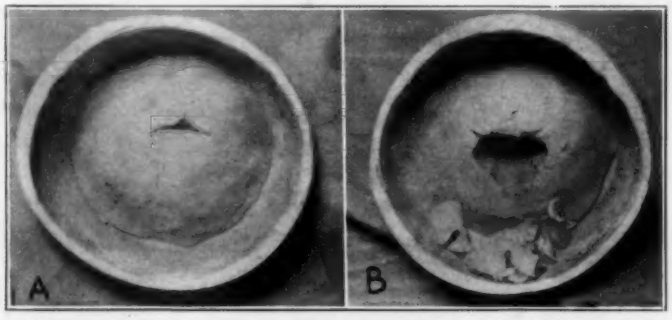


FIG. 9.—Model reproduction of a severe contracture or fibrosis of the bladder neck as found in case 2. *A*, shows the appearance of the bladder neck as visualized cystoscopically through the suprapubic fistula when the calculi were removed. The severe contracture was undoubtedly the cause for failure of automaticity to develop previous to resection. *B*, shows reconstruction of the type of resection performed. The patient voided automatically after resection.

dwelling urethral Foley catheter. We believe that this severe fibrosis of the neck of the bladder was caused by the poorly placed suprapubic catheter, which was resting against the neck for one and a half years. Two weeks after resection the patient urinated spontaneously for the first time in two years since his injury and the amount of residual urine was 60 cc. Figure 9*B* shows the type of resection performed; only 5 Gm. of tissue was removed. Resection in this case, we believe, allowed the bladder to resume its automatic cycle.

Resection in a total of 3 patients, 2 with a definite fibrotic contraction and 1 with obstruction from the median bar of the prostate, has resulted in the development of an automatic bladder in 1, decrease in residual urine in the second and no apparent improvement in the third. The third patient (case 36), though he had a filiform stricture and definite rigidity and tightness of the bladder neck, was also found to have a tight external sphincter. Resection of 10 Gm. of the bladder

neck after a course of urethral sounds resulted in improvement and in a urethra of good caliber, but retention persisted. The external sphincter was then deliberately coagulated. After this procedure, his suprapubic fistula closed and he was able to void, with 100 cc. of residual urine. In another patient the pressure in the bladder was 120 mm. with voluntary abdominal pressure, but considerable straining was required to empty the bladder. As a result of this high pressure and in spite of a residual urine of only 30 cc., the suprapubic fistula reopened every three to four weeks, necessitating insertion of a Foley urethral catheter each time to heal the fistula. Inspection of the bladder neck disclosed an exteremely tight external sphincter. As the loop of the resectoscope was passed over this sphincter a coagulating current was applied. This was done in the hope of weakening the muscle partially. Since then the suprapubic fistula has remained closed, and he has volunteered the information that he can pass water freely and with less effort. He does not dribble between voidings. This procedure of coagulating the external sphincter has been done in a total of 3 cases to date, with development of automaticity in 2 and a decrease of residual urine in the third. It is believed that automaticity will develop as the tone of the external sphincter decreases. This demonstrates the value of weakening the sphincter in cases in which

TABLE 2.—*Results of Transurethral Operations for Urinary Retention*

| Case<br>Age<br>Level of Injury | Preoperative Condition | Operation | Results |
|---|---|---|---|
| 2<br>26<br>L4 | Complete urinary retention without catheter<br>Diagnosis fibrosis, of the bladder neck | Resection of fibrotic bladder neck (5 Gm.) | 60 cc. of residual urine, with automatic voiding (1st time in two years) |
| 19<br>23<br>L2 | 5 cc. of residual urine only, but suprapubic fistula will not heal owing to severe pressure necessary to urinate (82 to 120 mm. Hg.)<br>Diagnosis: spastic sphincter | No intrusion of the bladder neck; spastic sphincter coagulated lightly | Urinates with less effort; only moderate effort necessary to force water out; fistula closed |
| 18<br>30<br>D8 | 250 cc. of residual urine; needs catheter to prevent discomfort of the bladder<br>Diagnosis: spastic sphincter | No intrusion of the bladder neck; spastic sphincter coagulated | 50 cc. of residual urine, but occasionally up to 150 cc. |
| 34<br>L3 | Automatic voiding, but with 700 cc. of residual urine (more of an overflow)<br>Diagnosis: Median bar obstruction | Resection of the median bar (4 Gm.) | Carries 250 cc. of residual urine without catheter; is more comfortable with an F16 Foley catheter |
| 36 | Need of suprapubic catheter; urinary retention develops when catheter is clamped off | First operation: resection of 10 Gm. of fibrotic bladder neck | No change |
| 26<br>C6 | Suprapubic catheter is out; Patient is using a Foley F16 urethral catheter and prefers urethral drainage to suprapubic<br>Diagnosis: Fibrosis of the bladder neck and spastic sphincter | Second operation: weakening of spastic external sphincter with coagulating current | Has 100 cc. of residual urine; suprapubic fistula closed; automatic |

there is a spastic sphincter and in which retention of urine persists in the absence of obstruction of the bladder neck. Therefore, we do not believe that resection of a normal bladder neck in itself will be of benefit in correcting retention of urine in these cases (table 2).

V. *The Control of Associated Incontinence.*—Along with every automatic type of urination there is an associated and occasional incontinence, usually manifesting itself at times of stress. This occurs

FIG. 10.—Our modification of the Davol urinal which is helpful to wheel chair patients with automatic bladders who have an occasional dribbling. Such an arrangement permits physical activity and increases the feeling of safety and comfort. It consists of a Penrose drain or soft dental gum rubber cemented into the form of a tube of appropriate diameter. It allows for periodic and uncontrollable erections to which these patients are subject.

during exercise programs or when the patients are swinging their legs in and out of bed. Wetting is taken care of by issuing to each patient various day and night rubber urinals that are on the market. These give a feeling of security and allow for several hours of absence from ward or bed. Many patients can go for the greater part of the night without urinating, and hence they do not sleep with their urinals. Another device that is most valuable, if used wisely, is the Cunningham clamp. Patients use it for short periods only, i.e., when getting

out of bed or while going from their beds to the bathroom or during gymnasium periods. A third device which we use is the apparatus depicted in figure 10. This consists of a 6 inch (15 cm.) piece of one and one-half inch (4 cm.) Penrose drain which is attached to a glass tube and then to the lower half of a rubber urinal reservoir. The other end fits snugly around the shaft of the penis. This can be worn for long periods and causes no localized areas of pressure. This last method is also of value to patients who refuse catheterization or who are intolerant to catheters, are constantly dribbling and may be continually activating bedsores. This device also allows for the periodic and uncontrollable erections that occur without causing pressure sores or discomfort.

VI. *Urinary Complications.*—In this series of 42 patients there has been only 1 case of persistent recurrent pyelitis. This was case 12, in which there was a stag-horn calculus in the right kidney. All attacks of fever ceased immediately after removal of the stone, and the pyuria also cleared. In several other cases, isolated and single attacks of fever of unknown origin, which were not due to epididymitis and may possibly have been due to pyelitis, have responded to a course of penicillin and sulfadiazine. Since streptomycin has been available infections caused by Bacillus proteus and Bacillus coli as well as by other gram-negative bacilli have been under much better control than heretofore.

Of the 42 patients, 8 had complications of the lower part of the genitourinary tract. These were patients with large urethral catheters and the complications were as follows: Four had periurethral abscesses, in 2 of whom urethral fistulas developed, and 4 had acute epididymo-orchitis. In 2 of the latter the condition resolved after treatment with penicillin and sulfadiazine, and in 2 it terminated in testicular slough. Creamy pus was found in the hydrocele cavity of both of these. The testicles were removed surgically. Substitution of F16 or F18 Foley catheters connected to a closed two way clamp irrigating system has brought to a minimum the incidence of epididymitis. Many patients have worn a catheter of this size, with weekly changes, for six to eight months and have had no complications. Large Foley catheters, F24 and F26, are therefore definitely to be avoided. Straight catheters which must be fastened to the penis with adhesive tape are mentioned only to be condemned. Not only are they untidy and foul smelling, but the tendency of these patients to have repeated involuntary erections makes this arrangement unsatisfactory.

VII. *Urologic Care of Patients with a Tendency to Formation of Calculus.*—Of the 42 patients studied, 19, or 45 per cent, had urinary calculi. Of these, 4 had stones in the kidney and 16 had calculi in the bladder. One patient had both. There were no recurrences of

the stones among ambulant patients. There were 2 cases in which stones reappeared in the bladder after reconfinement of the patients to bed for two months for plastic operations. There was a recurrence of a ureteral calculus one and one-half years after removal of a renal stag-horn calculus, which passed spontaneously (case 18). Stones do not seem to recur when physical activity is promoted and sufficient fluids ingested. Hence our first objective has been early exercises by means of weight-pulling attachments to the bed and then later by use of the wheel chair. Of course when severe bedsores prevent the patient from sitting up in a wheel chair this program must wait until the sores are healed either by primary granulation or by direct approximation of skin edges or flap grafts. The latter method is by far the quickest and most satisfactory, producing a well padded covering over eroded bony surfaces. Results of the surgical repair of decubitus ulcers in paraplegic patients have been published[13].

Diet as a Preventative of the Formation of Stones: Our main concern was the provision of ample nourishment because of the anemia and the protein loss in many of the patients who were in the process of having their decubitus ulcers healed. Dietary programs attempting to follow a strict acid-ash regimen for these patients have met with failure in our hands. Therefore, it seemed that any reevaluation of the ends in view would certainly point toward the fact that nourishment was the primary factor and the formation of the stones the secondary one. We recognized that we had to give food which the patients liked if any progress was to be made. This conclusion was based on the following factors:

1. Recent research has demonstrated a large daily loss of protein as a result of decubitus ulcers[14].

2. For the purposes of morale, when an aid to morale was most definitely needed, it was exceedingly important to serve tasty meals.

3. It was difficult to control the diet, since there has always been an excess of candy, effervescent drinks and fruit furnished to these patients by various organizations (all these items would be definitely contraindicated in any strict acid-ash regimen).

4. In our series of 42 cases there had been recurrence of stones in only 3 when a simple unrestricted high protein diet was given. Those were cases in which small stones reappeared in the bladder and ureter in patients who were reconfined to bed for various reasons.

Therefore, it seems that a strict acid-ash program should be limited to those in whom there is to be a tendency toward the formation of stones, who may be confined to bed but do not have decubitus

13. Freeman, B. S.: Treatment of Bed Sores in Paraplegic Patients, Surgery **21**:668-674 (May) 1947.

14. Barker, D. E.: War Wounds of Spinal Cord: Surgical Treatment of Decubitus Ulcers, J.A.M.A. **129**:160 (Sept. 8) 1945.

ulcers and who are also in a good state of nutrition. If all these conditions are not present, a high protein diet should be given. The explanation of this fact may be found in the recent observation of Dr. Charles Higgins that a high protein diet can serve as a basic acid ash diet[15].

Inactivity and prolonged rest in bed definitely furnish a multiplicity of factors predisposing to formation of stones in the urinary tract, notably atrophy of the bone structures from disuse causing excess excretion of calcium by the kidneys, which along with stasis due to inactivity and with alkaline urine, will precipitate the calcium

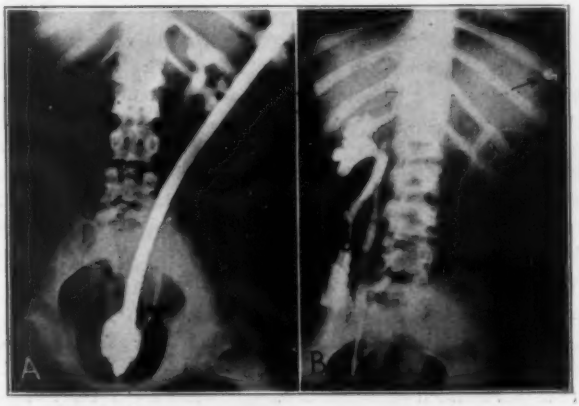


FIG. 11.—Unusual complications in a patient with injury of the spinal cord. Photographs show a machine gun bullet lodged in the diaphragm after transecting the spinal cord at the level of the eighth dorsal vertebra and the right ureter at the ureteropelvic junction. *A*, bilateral reflux of urine to the kidneys. *B*, injection of "skiodan" into the fistula over the right hip produced a retrograde pyelogram on the right side.

phosphates and carbonates in the production of the calculi. Hence periodic roentgenologic examinations for early recognition of calculi and for their removal as soon as possible are valuable.

There has been no recurrence of urinary calculi in any patient in this series in whom stones have been originally surgically removed when they have remained active and taken sufficient fluid along with adequate vitamin therapy.

Alternate courses of ammonium chloride and of methenamine to keep the urine from being highly alkaline have been used occasionally as well as alternating courses of sulfonamide medication and penicillin therapy for persistent pyuria. More recently, of course, we have had at our disposal streptomycin for the pathogenic gram-negative bacilli, which was not available at the time of most of these observations.

15. Higgins, C.: Management of Ureteral Calculi, read before the Aux Plains Medical Society, Oak Park, Ill. Jan. 24, 1947.

To patients on whose catheters calcified crusts persistenly formed, of whom there were fortunately only 4 in the entire series, "G" citric acid solution was given twice a day as a bladder-irrigating medium for a half hour period of retention. This prevented both frequent change of the catheter and the danger of damage to the urethra in pulling out an encrusted catheter. Incidentally, the effects of this solution were remarkable. Catheters that previously were repeatedly coated with hard crusts in the course of four to five days came out of the bladder after one week almost as clean as when they were put in.

VIII. *Summary of Causes of Death.*—Of the 42 patients studied, 4 died.

Case 23 (fig. 11).—The patient, aged 22, had extensive decubitus and trochanteric ulcers; the trochanters were protruding through the skin. There was also extravasation of urine from a gunshot wound in the right ureteropelvic area, causing a large infected pocket in the right flank, which drained through the ulcer of the right hip. Besides this, a suprapubic catheter had been inserted, and there was bilateral reflux of urine to the kidneys. He had spastic paraplegia and was emaciated. Postmortem examination was not allowed, but it was our impression that he succumbed to an overwhelming infection with septicemia, pyelonephritis and severe loss of protein due to the ulcers. The use of plasma, penicillin and blood transfusions was of no avail.

Case 5.—The death of this patient, aged 26, was due to cerebrospinal meningitis. Postmortem examination revealed penetration of a deep but not extensive sacral decubitus ulcer into the spinal canal. The same organism was found in the spinal fluid that was isolated from the decubitus ulcer on culture, namely, a mixed strain, with B. proteus predominating. Bacillus proteus was also recovered from the blood cultures. He had a stormy course, with a temperature of 105. F. for four days, which terminated in death.

These were early cases in our series, and streptomycin was not available at the time.

*Case* 10.—The patient, aged 23, went into a coma with facial paralysis on the left side and died in four days. The nonprotein nitrogen and blood sugar contents were normal during the coma, but he had a blood pressure of 150 and pulse rate of 110 previous to this episode. During the coma he had acute auricular fibrillation. Postmortem examination was not allowed in this case, but it was believed that death was due to a cerebral accident and thrombosis on the basis of endocarditis. There was no pyelonephritis or urinary calculi present. Drainage and irrigation by means of a urethral catheter had been carried out for the past two months, with suprapubic catheterization previous to this.

*Case* 33.—The patient did not die under our care but died one month after being discharged from the hospital to his home. The cause of death is not known. However, during his stay in the hospital he had trochanteric decubitus ulcers, a blood sugar content of 250 mg. and extremely purulent urine. He refused treatment in the hospital, catheter drainage and diabetic management. A report from his family physician one month after his discharge from our hospital stated that death was from pyelonephritis and uremia. Autopsy was not performed. The last roentgenologic examination had revealed no urinary calculi.

## SUMMARY

Of 42 patients with transections of the spinal cord, 20 had received bullet and shrapnel injuries of the spinal cord, and 21 had fractures of the vertebrae. In 12 cases, the fracture was caused by an accident in a jeep or a truck, in 1 by a collapse and in 1 by a blow from the tail of an airplane. Two patients had fallen on their heads during diving, 3 had a motorcycle accident and 2 an accident on a horse and 1 had infectious myelitis and meningitis.

Of the 42 patients, 4 died; 3 died in the hospital from apparent nonurologic causes, and 1 died at home from pyelonephritis and uremia. Of the 38 remaining under our care for the past year, 32, or 84 per cent, have automatic bladders, and 6 still need catheters. Of the 6, 2 have quadriplegia and associated paralysis of the arms, 2 have paraplegia, with flaccid abdomens and bladders and large amounts of residul urine, 1 has spastic paraplegia and will need a retention catheter until an anterior rhizotomy is performed to prevent continual dribbling and 1 is able to urinate automatically but is using a catheter because of extensive bedsores and numerous plastic operations.

Of the 42 patients, 19, or 45 per cent, had urinary calculi. The stones did not recur in the ambulant patients; there were 2 cases in which stones reappeared in the bladder after a two month reconfinement to bed for plastic operations for decubitus ulcers.

Of the 38 patients under care, 5 were subjected to operations on the neck of the bladder for urinary retention; these included both resection for fibrosis of the bladder neck and coagulation of a spastic external sphincter. Three improved to the extent that they can urinate automatically and do not need catheters; in 2 others there was a definite decrease in the amount of residual urine, but they need catheters for occasional retention.


## TWELVE RULES REGARDING THE CARE OF THE PARALYZED BLADDER

The following twelve rules have helped us in the management of patients with paralyzed bladders:

1. Periodic roentgenologic examinations of patients for recurrent formation of stone, especially those in whom there is a tendency toward such formation and who have been reconfined to bed, should be instituted. Removal of calculi should be done immediately, before recurrent pyelitis and fever reduce the patient to a condition in which he will be a poor risk for operation.

2. A closed system of irrigation of the bladder, attached to the bed, to be used with a two way clamp for frequent dilation and irrigation, is recommended. The object is to keep the bladder clean and elastic so that when automaticity does set in it will be in a proper condition to respond favorably. This also keeps the bladder from becoming a small, contracted, infected organ.

3. The use of boric acid solutions, acriflavine solution or isotonic solutions of sodium chloride for lavage and dilation of the bladder is suggested. "G" or "M" citric acid solutions are used for cases in which there is a tendency for the catheters to become encrusted. Removal of an encrusted catheter is almost a sure way to produce a periurethral abscess with a possible extravasation of urine.

4. A small Foley retention catheter, F16, F18 or F20, is used in all cases. The large Foley catheters such as F24 and F26 should be definitely avoided because of the danger of urethral trauma and of associated complications such as recurrent epididymitis, periurethral abscess and urethral fistulas. Straight catheters necessitating taping to the penis are to be condemned. The inflexible tape will not allow for involuntary erections, and penile ulcerations form easily. Changes of urethral catheters once every six to seven days, if they are not encrusted, will prevent urethral complications.

The wetting from involuntary urination and periodic dribbling are controlled with day and night rubber urinals and with the careful use of the Cunningham clamp. These procedures are especially helpful during the exercise program.

5. A high protein, high vitamin diet is necessary because of anemia and loss of protein from decubitus ulcers. The value of a strict acid-ash diet for the prevention of the stones is questioned because of the need for an attractive and nourishing diet, the difficulty of controlling the patients' diets and the absence of recurrence of stones when physical activity is begun.

6. Frequent trials at urination along with single cystometric readings to determine the pressure and capacity of the bladder and of the amount of residual urine will help to decide when the patient is ready for automatic control. The removal of catheters at the earliest possible time is recommended.

7. Periodic courses of sulfonamide drugs, penicillin and streptomycin should be given for occasional attacks of fevers, which are usually due to epididymitis or to recurrent pyelitis.

8. Promotion of early ambulation and exercise along with an adequate fluid intake and a high vitamin diet has prevented the recurrence of stones. Strengthening of the abdominal muscles because of their action as secondary muscles of urination helps to decrease the residual urine in the hypotonic bladders.

9. Early surgical repair of large decubitus ulcers, by promoting quicker healing and earlier ambulation, prevents formation of calculus and loss of proteins.

10. Anterior rhizotomy in suitable cases often transforms the troublesome, dribbling bladder to a well acting automatic bladder by changing paralysis from a spastic type, with its associated frequent mass reflex, to a flaccid type.

11. Investigation of the bladder neck for a possible fibrosis or for the formation of a median bar is recommended when retention of urine persists. Weakening of a spastic external sphincter by coagulation will often allow automaticity to develop in cases in which there is good bladder tone, slight retention of urine and no evidence of obstruction or fibrosis.

12. It is felt that any successful program must provide for the division of the patients into small groups, with at the most 30 to 40 in a group, under the care of one physician or ward surgeon. This physician should have at his call neurosurgical, surgical, urologic and orthopedic specialists and plastic surgeons. The patients must be under constant observation by the department of physical medicine and in continuous contact with the diet kitchen; there must be continuous nursing supervision for the care of dressings, the turning of patients and the treatment of bedsores and of postoperative wounds. There will have to be a well trained male attendant or nurse on day and night service who can take care of the necessary problems associated with the use of catheters. The attendant should definitely not alternate in giving the necessary and frequent enemas because of the danger of urinary contamination.

## FINAL NOTE

We have believed all along that if we could bring the patient to a condition in which he was able to move about in a wheel chair, urinate automatically, be entirely free of decubitus ulcers and calculi and be gainfully occupied at some hand-working occupation we would have corrected the most confining and disagreeable complications.

Whether the patients will all be able to attain a 100 per cent social or economic adjustment remains to be seen. It is a little too optimistic to expect this of all of them; however, there is among our patients a smaller group who have shown an amazing improvement and response. These, of course, have provided strong incentives to their less adaptable colleagues. Although a great majority have improved to a degree which allows them to attend baseball games, go swimming, ambulate in a wheel chair and spend some time on their artificial legs and crutches, there is still a big gap between this and that condition compatible with full economic adjustment.

Therefore, in conclusion, it would seem that any ideal plan of management will have to have some part time arrangement for these patients to earn their living. The several well organized veterans' hospital centers should be used as bases for their inevitable and frequent reexaminations and treatment.

435 South Vine Street.

# CONGENITAL CYSTIC DILATATION OF THE COMMON BILE DUCT

## Report of a Case

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THE PURPOSE of this communication is to report a case of congenital cystic dilatation of the common bile duct which was treated successfully by a Roux en Y anastomosis between the cystic dilatation and the jejunum. Apparently this procedure has not been reported heretofore as a method of establishing a satisfactory connection between the biliary and the gastrointestinal tracts in the treatment of this rare lesion[1].

### CASE REPORT

F. M., a 30 year old white man, an office worker, was admitted to Mercy Hospital on Feb. 3, 1946 because of epigastric discomfort and nausea. Much of his history has been obtained from relatives since his operation and discloses that as an infant he had episodes of gastric disturbances which became more frequent at about the age of 5. It was remembered that he was always underweight and had a sallow complexion. Beginning at the age of 6 and recurring during childhood, he had spontaneous hemorrhages under the skin of the legs and was given a diet containing gelatin as a part of the treatment. At the age of 7 and again at 15, the patient was struck in the epigastrium by a baseball, and there followed in each instance an attack of nausea and vomiting. At the age of 18, there began a series of attacks of upper abdominal pain and on February 3 the patient was admitted to attacks were followed by jaundice. While in high school, he was thought to have a "bad heart" and was not permitted to participate in competitive games.

In December 1939, at the age of 23, a more severe attack occurred; epigastric pain became moderately severe and was followed by nausea and jaundice. He consulted a physician, who prescribed some medicine and a fat-free diet which he followed until February 1941, when a dull pain in the right upper quadrant associated with nausea and vomiting occurred. These symptoms became so severe that he went to bed. The next day jaundice was present. He was in bed for four days. Thereafter he became ambulatory but remained jaundiced for two weeks. Another attack in March of 1943 was more severe but with less jaundice and required twenty-eight days of bed care. During January 1946 there were several less severe

Read by title at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

From the Division of Surgery, Mercy Hospital and the Department of Surgery, Loyola University School of Medicine.

1. Shallow, T. A.; Eger, S. A., and Wagner, F. B.: Congenital Cystic Dilatation of the Common Bile Duct, Ann. Surg. **117**:355-386, 1943.

attacks of upper abdominal pain and on February 5 the patient was admitted to Mercy Hospital for a series of diagnostic procedures.

At that time the physical examination revealed a fairly well developed, mildly undernourished white man who was neither uncomfortable nor acutely ill. The general physical examination revealed no significant abnormalities except moderate and diffuse tenderness in the upper right quadrant. The blood pressure was 125 systolic and 80 diastolic. The laboratory studies disclosed: hemoglobin 14.5 Gm., red blood cells 4,700,000, white blood cells 5,100, with a normal differential count, non-protein nitrogen 30 mg., calcium 12 mg. and blood sugar 57 mg. per hundred cubic centimeters, an icteric index of 10 clinical units and cholesterol 140 mg. The urine was normal. The prothrombin level disclosed 63 per cent of normal activity. Bile and blood were found in the stools. Studies of the gastrointestinal tract with barium revealed findings interpreted as indicating an active duodenal ulcer with some degree of pyloric obstruction. Oral cholecystography failed to demonstrate a gallbladder shadow. It was thought advisable to treat the patient medically for a time to heal the ulcer and to remove the gallbladder at a later date. After the medical management had been established, the patient was dismissed from the hospital on March 14, 1946. One week later he had another attack of pain, but this subsided spontaneously and he remained comfortable until his readmission in April 1946.

Interval roentgen studies showed improvement in the ulcer and operation for relief of the gallbladder disturbance was planned. Preoperative laboratory studies disclosed 100 per cent prothrombin activity. Quick's hippuric acid test for liver function revealed recovery of 0.54 mg. (0.7 to 0.95 normal).

*Operation.*—April 10, 1946: With the patient under general anesthesia, an upper right rectus incision was made, the anterior sheath was incised, the muscle was retracted laterally, and the peritoneum was opened. Presenting at the midportion of the wound was the junction between the first and second portions of the duodenum. This point was displaced inferiorly by a cystic mass 12 by 15 cm. in diameter lying above it (fig. 1*A*). The gallbladder was found to be rather elongated, the fundus extending for almost 5 cm. beyond the edge of the liver. The gallbladder was normal except for some thickening of its wall and mild hyperemia beneath the serosa. No stones were palpated in the gallbladder, no adhesions were encountered in the area, and the foramen of Winslow was patent. The cystic mass protruded from behind the peritoneum, presented above the duodenum and was independent of the pancreas. It was distended but not tense and was bluish white with a thin wall. A diagnosis of congential cystic dilatation of the common duct was made promptly. On opening the cystic swelling, it was found to contain greenish brown bile and six smooth, round, yellowish white stones (fig. 2). An opening in the distal portion of the cyst was found and through it an olive-tipped probe was passed with ease into the duodenum (fig. 1*A*). The stones were removed. Further exploration disclosed the cyst to be connected with the upper biliary tract at the superior pole of the cyst by a duct which admitted the index finger easily. The cyst was not further mobilized. The proximal loop of jejenum was brought up and divided. The distal end of this loop was anastomosed in an end to side manner to the cystic dilatation of the common duct. An end to side anastomosis between the proximal stump of the divided jejunum and a point on the antimesenteric border of the jejunum about 12 inches (30.48 cm.) distal to its point of division was made, a Roux en Y anastomosis thus being established (fig. 1*B*). The defect in the mesentery was closed. In both anastomoses, an outer row of interrupted mattress sutures of silk and an inner Connell suture of 0 chromic surgical gut were used. The gallbladder was drained with a mushroom catheter.

In attempting to identify a bleeding point medial to the cystic dilatation, an

opening was inadvertently made in the friable cyst wall and some bile escaped. This opening was closed by two rows of interrupted silk sutures. A drain was placed

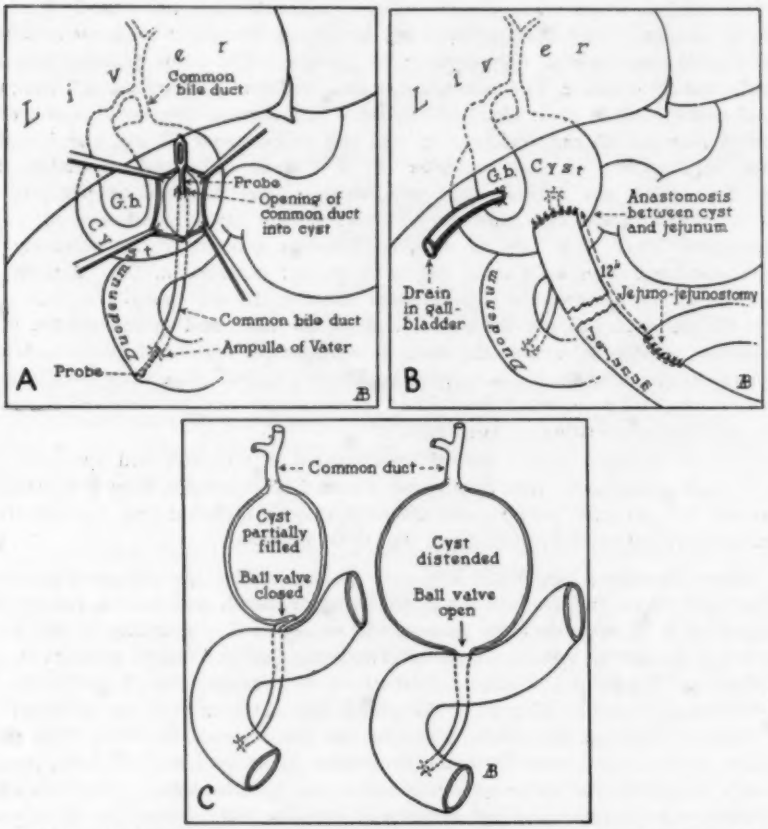


FIG. 1.—*A*, the cyst has been opened. The opening into and connection with the common duct are indicated by the position of the probe, *B*, Roux en Y anastomosis connecting the opening in the cyst wall and the jejenum. A drain has been placed in the gallbladder. *C*, probable mechanism of obstruction in congenital cystic dilatation of the common bile duct.

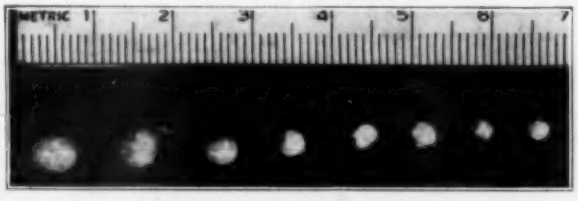


FIG. 2.—Eight stones from 3 to 8 mm. in diameter found in the cystic dilatation of the common duct.

in this area draining the retroperitoneal space around this cyst, from which there was still a little oozing. The abdomen was closed about the catheter draining the gallbladder and the Penrose drain at the upper angle of the incision. The patient

was returned to his room in fair condition. During the operative procedure, he received 1,000 cc. of plasma and 500 cc. of whole blood.

*Postoperative Course.*—Additional transfusions were given to combat moderate but resistant shock in the immediate postoperative course. Atelectasis of the lower lobe of the right lung developed and rapidly progressed to involve the entire lung. Bronchopneumonia followed, and fluid was later shown to be present in the right pleural cavity. As the respiratory complications were clearing at the end of two weeks the prothrombin time, which had been 100 per cent at the time of operation, had fallen to 40 per cent, and on the eighteenth and nineteenth days both tarry stool and bright red blood were passed by rectum. The patient was not in shock at this time, and it was thought that this complication represented spontaneous hemorrhage from the bowel on the basis of hypoprothrombinemia

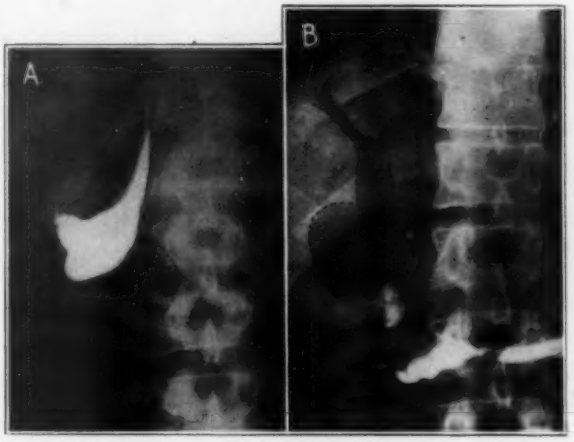


FIG. 3.—*A*, gallbladder outlined by iodized oil introduced through cholecystostomy fistula on the forty-fourth postoperative day. Part of cystic dilatation is outlined on roentgenograms by gas as indicated. Roentgenogram taken May 24, 1946. *B*, eleven months later the common bile duct, the right and left hepatic ducts and the cystic dilatation of the common bile duct are outlined due to the presence of gas from the jejunum. A small quantity of barium has been carried toward the biliary tract one hour after a barium meal. Roentgenogram taken March 29, 1947.

rather than bleeding from a peptic ulcer. Transfusions and massive doses of vitamin K were given, and the bleeding stopped.

Up to this time, gastric suction had been necessary and the problem of adequate nutrition by parenteral route became so great that a jejunostomy for feeding purposes was done on the twenty-fourth postoperative day (May 14, 1946). Feedings through the tube were begun, and in four days there was sufficient improvement to warrant removing the gastric suction tube. On the morning of the twenty-ninth postoperative day (May 9, 1946) the right leg was found to be swollen and edematous, with tenderness in the calf and a positive Homan's sign. Ligation of the right femoral vein under local anesthesia was immediately performed and thereafter the pain and swelling in the leg subsided. General improvement continued; the patient was out of bed on the forty-first postoperative day. On the forty-fourth postoperative day, iodized oil was injected into the gallbladder through the cholecystostomy fistula and roentgen studies disclosed complete obstruction of the cystic duct (fig. 3*A*). The patient was dismissed on the fifty-seventh postoperative day (June 6), weighing 95 pounds (43.1 Kg.).

*Subsequent Course.*—The patient has had no digestive distrubance of any consequence in the eleven months which have elapsed since the operation. There had been no symptoms suggesting ascending cholangitis. When examined in April 1947, he weighed 147 pounds (66.7 Kg.) and was enjoying good health. Cholecystograms made at this time showed no dye in the gallbladder. The common bile duct, the right and left hepatic ducts and the cystic dilatation were filled wih air. Barium by mouth revealed no abnormality in the region of the duodenum. Roentgenograms taken one hour later showed the barium passing on down the small bowel, but a small amount had entered the upper limb of the Roux en y anastomosis in the direction of the biliary tract (fig 3*B*).

## COMMENT

Unlike many rare lesions which may be of academic interest only, congenital cystic disease of the common duct deserves special emphasis. Although the correct preoperative diagnosis is highly desirable and will be made more readily as the outstanding signs and symptoms are clarified, prompt recognition of the lesion when it is exposed at operation is imperative. If the condition is immediately recognized at operation, appropriate definitive procedures may be undertaken without delay and with good promise of satisfactory results. On the other hand, unnecesary and damaging dissection may be pursued if the condition is not recognized promptly. The cyst might be severed from all of its connections and excised before the nature of the lesion has been appreciated. The difficult problem of bridging a gap in the extrahepatic biliary tract then suddenly confronts the unwarned and unprepared operator.

That the lesion is rare is attested by Shallow's figures[2] published in 1946, at which time he was able to collect 182 authenticated cases. As in many other unusual pathologic conditions, there have undoubtedly been instances which may have gone unrecognized or unreported. It is not probable that there have been many such cases, so that the 182 reported cases is a fair indication of incidence.

The numerous possible etiologic factors and theories have been reviewed by Shallow[1] and appear to include all manners in which the known stages of development of tissues and organs in this area might grow abnormally. Undoubtedly there is some congenital factor which permits the retroduodenal portion of the common duct to develop normally while the supraduodenal part undergoes dilatation. The mechanism of its development is obviously of considerable interest, but it is doubtful that an understanding of it would prompt any earlier diagnosis or any alteration in therapy.

Among the clinical manifestations, abdominal pain, abdominal mass and jaundice have been noted so frequently that they constitute

2. Shallow, T. A.; Eger, S. A., and Wagner, F. B.: Congenital Cystic Dilatation of the Common Bile Duct; Follow-up on Previously Reported Case and Report of Additional Case, Ann. Surg. **123**:119-126, 1946.

a triad of symptoms which are almost diagnostic, as pointed out by Shallow[1] and Gross[3]. In 175 cases analyzed by Shallow, 77 per cent of patients had an abdominal mass, 70 per cent had jaundice, and 59 per cent had pain. These symptoms depend on the degree and duration of the obstruction at the junction of the cystic dilatation and the normal portion of the common duct (fig. 1*C*). The triad of abdominal pain, palpable mass and jaundice was not present in this patient. There is no record that a mass had ever been felt during the repeated examinations of this patient and only after years of episodes of abdominal pain did jaundice appear. In this case the history as recounted was not known to the patient but was obtained more or less piecemeal from members of his family following the operation.

Cholecystrograms rarely disclose a gallbladder shadow, and this case was no exception. On the forty-fourth postoperative day, injection of iodized oil U.S.P. through the cholecytostomy fistula showed no passage of opaque substance through the cystic duct in twenty-four hours. This finding demonstrates that obstruction of the cystic duct is the cause of failure in cholecystography in some instances rather than failure of the gallbladder to concentrate the dye as stated by Shallow[1]. At the time of the roentgenograms shown in figure 3, portions of the cyst and ductal system were outlined by air. Unless the cyst makes some significant deformity in the outline of the stomach or duodenum, roentgen studies with a barium meal are not helpful. From the situation disclosed at operation, one would expect a suggestive abnormality to appear in the gastrointestinal series. None was found. It is unlikely that efforts to demonstrate calculi will be of any aid. In the cases of McWhorter[4], Winterstein[5] and Sat[6] no mention was made of the roentgen diagnosis of stones, and the stones present in this instance (fig. 2) were not shown on the roentgenograms. These 4 are the only cases in which stones have been reported.

As in other long-standing disturbances in the biliary tract, a certain degree of damage to the liver should be expected. On a previous admission (February 1946) the prothrombin time had been brought up to normal after an initial value of 63 per cent. It was 100 per cent just prior to operation. However, results of the Quick hippuric liver function test were somewhat below normal. This was thought to be due to some variation in laboratory technic, but due

3. Gross, R. E.: Idiopathic Dilatation of the Common Duct in Children, J. Pediat. **3**:730-755, 1933.

4. McWhorter, G. L.: Congenital Cystic Dilatation of the Common Bile Duct, Arch. Surg. **8**:604-626 (March) 1924.

5. Winterstein, O.: Bile Duct Cysts: Diagnosis, Wien. med. Wchnschr. **82**:638-639, 1932.

6. Yotuyanagi, G.: Contribution of the Etiology and Pathogeny of Idiopathic Cystic Dilatation of the Common Bile Duct, Gann **30**:601-650, 1936.

to an oversight it was not repeated. The depression of prothrombin activity (40 per cent of normal) which occurred eighteen days after operation and which was held responsible for a forty-eight hour period of massive gastrointestinal bleeding was considered an expression of previous damage to the liver. The prothrombin level was restored to normal only after transfusions of whole blood and massive parenteral use of vitamin K.

As in the management of pyloric obstruction in general, the use of jejunostomy for feeding purposes proved to be an extremely valuable procedure[7]. Whether the pyloric obstruction was due to activation of a latent ulcer or to peripyloric inflammation is undetermined. At the time there was gastric retention, there was no abdominal distention, peristaltic sounds were present, and the bowels were moving. The obstruction therefore appeared to be due to a local cause. Within forty-eight hours after the jejunostomy, there was great general improvement in the patient's condition. Although there was a subsequent complication (phlebothrombosis), it was felt that the turning point in the postoperative course was the improvement after jejunostomy.

As has been pointed out, treatment begins with recognition of the true nature of the condition. Even if the possibility of congenital cystic dilatation of the common duct is not considered, the well recognized maneuver of aspirating a mass of unknown nature (providing it does not pulsate) will establish the mass as being connected with the biliary tract. The cyst thereupon could be opened safely, and its extent and connections determined before irretraceable steps in dissection are undertaken. With this general plan one would avoid the possibility of extirpating the cyst only to be confronted with the complicated task of anastomosing the stumps of the bile ducts to the duodenum or stomach.

Extirpation of the cyst with primary anastomosis to the duodenum is the most physiologic procedure, advises Shallow, because the cyst harbors infection. Undoubtedly bacteriologic examinations were not done in most cases but the contents have been found to contain organisms in only 7 instances. Since stasis in any ductal system predisposes to infection, adequate drainage by anastomosis to the gastrointestinal tract seems to be the most essential consideration. Numerous connections between the biliary and gastrointestinal tracts have been described ranging from direct simple anastomoses to various types of connections designed to function as a valvular arrangement[8]. The

7. Allen, A. W., and Welch, C. E.: Jejunostomy for the Relief of Malfunctioning Gastroesterostomy Stoma, Surgery **9**:163-182, 1941.

8. Zollinger, R.: A Method of Valvular Cholecystgastrostomy, Surg., Gynec. & Obst. **70**:71-78, 1940.

use of the Roux principle with valves as described by Cole[9] or without as described by Allen[10] appears to have an advantage over other previously suggested arrangements. The Roux en Y anastomosis seems to provide a connection with minimal possibility of regurgitation of intestinal content, thus avoiding ascending cholangitis. In this case, roentgen studies eleven months after operation showed only a few flecks of barium in the segment of the jejunum leading to the biliary tract, but large portions of the cyst and common duct were outlined by gas (fig. 3*B*).

Little can be said concerning the subsequent course of patients with congenital cystic dilatation of the common duct. Of the 182 patients in Shallow's collected series, comment concerning the later results were available for only 9 patients. Three patients were well four years after operation and 6 were well for more than five years. Since 76 per cent of the patients were younger than 25 years, perhaps the literature in the future may contain some information regarding their subsequent course. Since the effects on the liver are not different from those resulting from uninfected benign biliary obstruction, it seems safe to predict that the end results in the surgical treatment of congenital cystic disease of the common duct will closely parallel those found in treatment of benign stricture of the common duct.

Improvement in the preoperative management to correct malfunction of the biliary tract, improvements in the type of anastomoses, particularly the use of the Roux en Y principle, and the better understanding of the disturbed hepatic physiology will bring about better results in the treatment of benign structure and will also improve the results in management of congenital cystic disease of the common bile duct.

SUMMARY

A case of congenital cystic dilatation of the common duct is reported.

This is the fourth case on record in which calculi were found in the cystic dilatation.

This appears to be the first instance in which the Roux en Y principle has been used to establish a suitable communication between the cystic dilatation and the gastrointestinal tract.

During the eleven months which have elapsed since the operation, there have been no signs or symptoms of ascending cholangitis or any other complication.

30 North Michigan Avenue.

9. Cole, W. H.; Ireneus, C., Jr., and Reynolds, J. T.: The Use of Vitallium Tubes in Structures and Absence of the Common Bile Duct, Ann. Surg. **122**:490-521, 1945.

10. Allen, A. W.: A Method of Re-Establishing Continuity Between the Bile Ducts and the Gastro-Intestinal Tract, Ann. Surg. **121**:412-424, 1945.

# COMPARATIVE RESULTS IN OPERATIONS FOR PILONIDAL CYSTS

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IN THE ARMY there was an excellent opportunity to develop a satisfactory curative operation for the treatment of pilonidal cysts and sinuses. A satisfactory method was developed only after several procedures had first been tried which in 1942, when this work was begun, were considered adequate. The purpose of this paper is to compare the early and the late results obtained from various operative procedures.

The following operations were employed:

A. Block excision of the cyst and its ramifications followed by packing the wound open with petrolatum gauze and later with packs of diluted solution of sodium hypochlorite. The wounds healed by secondary intention.

B. Block excision followed by petrolatum gauze packing, packing with diluted solution of sodium hypochlorite and secondary skin grafts after a clean granulating area was established.

C. Block excision, with undermining and closure by means of retention sutures placed in the buttocks, with no suture material placed within the wound itself.

D. Block excision, with undermining and sewing of the edges of the skin to the sacral fascia after the principle described by Colp[1] and later by McFee[2] and Van Alstyne[3] and others.

E. Block excision, with undermining of fat or cutting into the muscles followed by primary closure prior to the establishment of the present technic.

F. The present technic of block excision without undermining, followed by primary closure with cotton suture material and

Read at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

1. Colp, R.: Treatment of Pilonidal Cysts and Fistulae, S. Clin. North America **9**:695, 1929.

2. McFee, W. F.: Pilonidal Cysts and Sinuses: Method of Wound Closure; Review of Two Hundred and Thirty Cases, Ann. Surg. **116**:687, 1942.

3. Van Alstyne, G. S.: Surgical Treatment of Pilonidal Cysts, with Description of Author's Method of Demarcation and Closure, Surgery **12**:782, 1942.

sulfanilamide crystals placed externally on the closed wound[4].

While these operations were used more or less in the order named, there was some attempt to select the operation in certain cases prior to the estabilshment of the present technic. For instance, for thin patients with a minimum amount of infection a primary closure was usually attempted, whereas when the patient was markedly obese and there was considerable drainage the wound was left open to heal by secondary intention and perhaps skin grafting carried out in an effort to hasten healing. After the present technic was evolved, all wounds

TABLE 1.—*Immediate Results*

| TECHNIC | Patients | Primary Healing | | Secondary Healing | | COMMENT |
|---|---|---|---|---|---|---|
| | | No. | % | No. | % | |
| A. Excision; petrolatum gauze pack | 6 | 0 | 0 | 6 | 100 | All patients grossly infected; healing time averaged 90 days with the exception of 1 case in which ischemic ulcer developed, which was excised and closed. |
| B. Excision; secondary skin grafts | 11 | 0 | 0 | 11 | 100 | All patients grossly infected; healing time averaged 120 days except for 4 cases in which ischemic ulcers developed, three of which were excised and closed. |
| C. Excision; tension sutures in buttocks | 2 | 0 | 0 | 2 | 100 | Both grossly infected, necessitating removal of tension sutures; healed by secondary intention; 1 left hospital in 46 days and the other in 110 days. |
| D. Excision; suture of skin edges to sacral fascia | 11 | 2 | 18 | 9 | 82 | Healing time averaged 61 days except for 2 cases; in 1 an ischemic ulcer developed requiring excision and primary closure and in 1 lesion was not healed four months after operation. |
| E. Excision; primary closure before present technic and after care | 10 | 5 | 50 | 5 | 50 | Of the 5 cases in which there was secondary healing, in 3 there was moderate infection, in 1 moderately severe infection and in 1 severe infection. |
| F. Excision; primary closure by the present technic | 225 | 218 | 97 | 7 | 3 | For further details see table 3. |

except acute abscesses were treated by the standard method of closure. Acute abscesses were incised and drained and acute inflammation allowed to quiet down before the curative operation was done.

## IMMEDIATE RESULTS

The immediate results are shown in table 1. When simple excision (operation A) was done, the average time necessary to heal

4. Larsen, B. B.: Pilonidal Cysts and Sinuses: A Technic for Excision and Primary Closure, Ann. Surg. **123**:1090, 1946.

by secondary intention was ninety days or one hundred and twenty days when the excision was extensive and followed by skin grafting (operation B). Skin grafts for these wounds were not successful because infection could not be controlled satisfactorily.

The technic of closing pilonidal wounds by means of tension sutures in the buttocks (operation C) was a poor one, and the less said of it the better. Both patients for whom it was tried did poorly.

The suturing of the edges of the skin to the sacral fascia (operation D) met with poor success. An absolutely accurate approximation of skin edge to skin edge was not obtained, and the wounds were invaded by bacteria. They became infected beneath the flaps, tension increased because of the swelling and the sutures pulled out or had to be taken out in 9 of 11 cases.

The ten operations in which primary closure was done prior to the present technic (operation E) were carried out in selected cases. In each instance the operation was performed on relatively thin persons in whom little or no infection, even of a chronic nature, was present. The poor results in these cases can be attributed to lack of experience, undercutting which at the time was thought advisable, the type of suture material used (in 6 of the cases the wounds were closed with surgical gut) and the lack of protection of the wound from invading bacteria during the immediate postoperative period. In 2 of the cases sulfanilamide was used both systemically and topically, with poor results.

The immediate results in the 225 consecutive cases in which the present tehcnic (operation F) was employed were surprisingly good. The operations were done before penicillin was available for prophylactic use. Its use when infection threatens apparently gives added protection. Table 3 presents a more complete summary of the recent results in these cases.

### LATE RESULTS

Follow-up was accomplished for the most part by the use of questionnaires mailed to the patients. Their permanent addresses were obtained at the time of operation. The response was exceedingly good. Only 27 of 265 patints failed to return their questionnaires. At least some of these 27 must have lost their lives in service.

The late result was considered unsatisfactory when drainage occurred after the wound had healed or when healing failed because of the formation of an ischemic ulcer. When prompt healing followed recurrent drainage due to one or two infected sutures which sloughed out or had to be removed, reexcision was not considered indicated. Also, if temporary drainage was due to abrasion of the epithelium

over the scar, reexcision was not considered indicated. Reexcision was considered indicated in all cases in which this had actually been done, in which there was repeated recurrent drainage or in which there was evidence of a true recurrence of the cyst such as the presence of subcutaneous hair. So far as could be determined, there were only 2 cases in the entire series in which recurrent cysts containing hair were found.

It is significant that in the 55 cases in which there were poor late results after the different procedures drainage first occurred within six months of operation in 49 and appeared for the first time after six months in only 6. In only 2 cases of the entire series did recurrent drainage first occur after one year.

TABLE 2—*Late Results*

| TECHNIC | Total Cases | No Drainage | | LATE DRAINAGE | | | | Average Follow-Up (Months) | Followed Less Than One Year |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Reexcision not Indicated | | Reexcision Done or Indicated | | | |
| | | No. | % | No. | % | No. | % | | |
| Excision; petrolatum gauze pack | 6 | 3 | 50 | 2 | 33 | 1* | 17 | 28.0 | 1 |
| Excision; secondary skin grafts | 11 | 4 | 36 | 3 | 27 | 4† | 36 | 36.7 | 0 |
| Excision; tension sutures in buttocks | 2 | 0 | 0 | 1 | 50 | 1 | 50 | 41.0 | 0 |
| Excision; suture of skin edges to sacral fascia | 11 | 4 | 36 | 3 | 27 | 4 | 36 | 36.1 | 0 |
| Excision; primary closure before present technic | 10 | 7 | 70 | 1 | 10 | 2 | 20 | 33.0 | 2 |
| Excision; primary closure by the present technic | 225 | 192 | 85 | 23 | 10 | 10 | 4 | 26.7 | 24 |

*Failed to heal because of ischemic ulcer.
†Reexcision in 3 of 4 cases because of ischemic ulcer.

It will be noted in table 2 that the present technic of primary closure and after-care resulted in superior late results as well as superior early results. Of 225 patients operated on, recurrent drainage occurred in 35. The drainage was of a minor nature in 23 cases, and reexcision was indicated in only 10. In 17 of these 33 cases recurrent draining was first noticed during the second month after operation. From table 3 it is evident that after primary healing recurrent drainage is not frequent and that when it does occur it is usually of minor importance. Reexcision of the area is seldom necessary after primary healing but may be frequently indicated after secondary healing.

PRESENT TECHNIC

The details of the present technic are described elsewhere.[4] Briefly the procedure is as follows:

Curative operation is not attempted in the face of acute infection. Abscesses are incised and drained, and acute infection is allowed to subside completely. At operation the patient is placed in the broken prone position, the buttocks are strapped apart, the operative site is cleansed and draped with moist towels and a towel clip is placed just

TABLE 3.—*Present Technic in 225 Consecutive Cases*

| | Immediate Results | | Late Results | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Late Drainage | | | | | |
| | No. | % | No Drainage | | Reexcision not Indicated | | Reexcision Done or Indicated | | Average Follow-Up (Months) | Followed Less Than One Year |
| | | | No. | % | No. | % | No. | % | | |
| **Primary Healing** | | | | | | | | | | |
| Absolutely per primam | 191 | 84.9 | 165 | 73.3 | 21 | 9.3 | 5 | 2.2 | 26.1 | 21 |
| Slight overlap of skin | 11 | 4.9 | 9 | 4.0 | 1 | 0.4 | 1 | 0.4 | 27.3 | 1 |
| Pressure necrosis of the skin edges (not over four sutures) | 2 | 0.9 | 2 | 0.9 | 0 | 0.0 | 0 | 0.0 | 26.0 | 0 |
| Cutaneous stitch abscess (immediate healing on removal of offending sutures) | 7 | 3.1 | 7 | 3.1 | 0 | 0.0 | 0 | 0.0 | 25.6 | 1 |
| Subcutaneous stitch abscess (immediate healing on removal of offending suture) | 7 | 3.1 | 6 | 2.7 | 1 | 0.4 | 0 | 0.0 | 26.3 | 1 |
| Totals | 218 | 96.9 | 189 | 84.0 | 23 | 10.2 | 6 | 2.7 | | 24 |
| **Secondary Healing** | | | | | | | | | | |
| Moderate infection (not over ¼ of wound) | 3 | 1.3 | 1 | 0.4 | 0 | 0.0 | 2 | 0.9 | 30.3 | 0 |
| Moderately severe infection (not over ½ of wound) | 4 | 1.8 | 2 | 0.9 | 0 | 0.0 | 2 | 0.9 | 29.2 | 0 |
| TOTALS | 7 | 3.1 | 3 | 1.3 | 0 | 0.0 | 4 | 1.8 | | 0 |

above the anus to avoid contamination from this area. Adequate elliptic block excision of the lesion is done so that only normal tissue is cut into and so that the edges of the wound are vertical or slanted from the skin toward the midline. Undermining or undercutting of fat or muscle is avoided. Bleeding points are tied with no. 80 cotton. The wound is irrigated with isotonic solution of sodium chloride and closed with no. 40 cotton sutures placed one row at a time, held and then tied. By pressing the buttocks together, one may determine at what depth the fat may be successfully sutured without undue ten-

sion. The level of this deepest row of cotton sutures is not the bottom of the wound, and any involvement of the sacral fascia by this layer of sutures is avoided. By placing sutures one row at a time before tying, it is possible to approximate widely divided tissues successfully without undue tension on any individual suture. At least two rows of subcutaneous cotton sutures are usually required, and for large, obese persons, three or more rows may be necessary. The skin is closed with interrupted cotton sutures which do not pass into the subcutaneous fat, thus giving some protection against invasion of the wound by bacteria. Sulfanilamide crystals are dusted on the closed incision externally, and a pressure dressing with mechanic's waste is applied. On the third postoperative day the sulfanilamide crystals are removed, and zinc stearate powder is applied and reapplied as often as necessary to keep the area dry. Patients are allowed up to the bathroom, but they should not sit on the stool. Skin sutures are removed on the seventh to the tenth posoperative day. Individual sutures are removed sooner if there is inflammatory reaction about them.

## CONCLUSIONS

Comparison of the immediate results obtained with the various operative procedures demonstrates the superiority of primary closure as outlined in this paper over the other methods tried. After this method of primary closure secondary healing occurred in only 7 of 225 consecutive cases. When primary healing of a properly excised and closed wound occurs, the resulting scar is minimal and there is an almost normal fat pad over the sacrum. After the other types of operations secondary healing occurred in from one half to all of the cases.

The late results also show the superiority of this method of primary closure over the other methods used. In only 4 per cent of these cases was reexcision indicated; after the other operations reexcision was indicated in 17 to 50 per cent of the cases.

# HABITUAL DISLOCATION OF THE SHOULDER JOINT

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RECURRING dislocations of the shoulder joint have been recognized for centuries, Hippocrates being credited with the first description. Over the course of time treatment has been varied. The first recorded treatment consisted of plunging a hot iron into the axilla. There was little rationale in methods used until about 1882, when Cromer[1] advocated resection of the head of the humerus. In 1888 Albert[2] advised fusion of the shoulder. By 1903 recommendations had become much less radical. They fall into four groups or combinations thereof. From about 1903 attention was focused on the capsule, the treatment consisting chiefly of plication operations. By 1909 the style shifted to muscle slings. Ehrlich and Clairmont advocated taking a segment of the posterior deltoid, freeing it from its insertion into the humerus, stripping it free up to its origin and then slipping it through under the head of the humerus extracapsularly and attaching it to the acromial process. In 1917 Joseph[3] introduced the principle of bony suspension by means of fascial slings. He drilled a transverse tunnel through the head of the humerus through which he threaded a strip of fascia and sewed its ends together over the acromial process. In 1921 Henderson[4] modified this technic by

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1. Cromer, F.: Resection des Oberarmkopfes wegen habitueller Luxation, Berl. klin. Wchnschr. **19**:21, 1882.

2. Albert, E.: Arthrodese bei einer habituellen Luxation des Schultergelenkes, Internat. klin. Rundschau **2**:281, 1888.

3. Joseph, E.: Eine neue Operation zur Verhütung des habituellen Schulterverrenkung, Berl. klin. Wchnschr. **54**:525, 1917.

4. Henderson, M. S.: Habitual or Recurrent Discolation of Shoulder, Surg., Gynec. & Obst. **33**:1, 1921.

drilling a tunnel through the tuberosity of the humerus and a second one through the acromial process and threaded a peroneal tendon through them. He gave the fact that the procedure is extracapsular and that tendon is stronger than fascia as the advantage of his procedure. In 1927 Carrell[5] used the biceps tendon as the suspending medium and in 1929 Nicola[6] used the same technic. At about this time Speed[7] and Gaenslen[8] independently worked out bone-grafting technics.

## CAUSATION

The cause of habitual dislocation of the shoulder joint was considered by most authors to be "some altered muscle tension" or capsular relaxation. In 1938 Bankart[9] pointed out that the anterior capsule is torn away from the rim of the glenoid and this allows the head of the humerus to dislocate over the anterior rim of the latter. He classifies primary or fresh dislocations into two types .One type occurs because the arm is hyperabducted. In this position the tuberosity of the humerus impinges against the acromial process. On increasing abduction the head of the humerus tears through the capsule inferiorly. The humeral head lies between the triceps and the subscapularis. When the arm is brought down to the side of the body, the head comes to rest anteriorly under the coracoid process. In the other type the elbow is at the side of the body and slightly posterior. If the elbow is struck the head of the humerus is forced forward and upward, tearing the capsule anteriorly from the rim of the glenoid. The rent never heals, and it is this type that causes the habitually dislocating shoulder. This is the mechanism enacted in football players and in epileptic patients.

## CLINICAL EXPERIENCE

Since the publication of Bankart's paper I have supervised operation on forty shoulders involving 38 patients, 12 of whom were reported on in 1942. [10]The average age of the patients was 23 years.

5. Carrell, W. B.: Habitual Dislocation of Shoulder, J.A.M.A. **89**:948 (Sept. 17) 1927.

6. Nicola, T.: Recurrent Anterior Dislocation of Shoulder: New Operation, J. Bone & Joint Surg. **11**:128, 1929.

7. Speed, K.: Common Dislocations, Am. J. Surg. **6**:517, 1929.

8. Gaenslen, F. J.: Orthopedic Surgery: Methods of Routine Examination, Wisconsin M. J. **27**:156, 1928.

9. Bankart, A.S.B.: Pathology and Treatment of Recurrent Dislocation of Shoulder Joint, Brit. J. Surg. **26**:23-29 (July) 1938.

10. Odgers, S. L., and Hark, F. W.: Habitual Dislocation of the Shoulder Joint, Surg., Gynec. & Obst. **75**:229, 234 (Aug.) 1942.

Three fourths of them were former servicemen. The lesions in this group were much more extensive than those found in civilians. The glenoid lip was seldom present in its entirety. In 3 cases it was completely absent as if it had been dissected surgically. The joints of these patients contained granulation tissue about the cartilage margin on the head of the humerus and around the rim of the bony glenoid. There were 4 cases in which the glenoid lip was torn away from the bony rim (fig. 2*A*, *1*) and the capsule was being dissected (fig. 2*A*, *2*) away from the neck of the scapula for a distance of three fourths of an inch (2 cm.) as if a subperiosteal elevator had been used. On the surface the capsule appeared intact and could easily be mistaken for a normal capsule. In 8 instances the tear was along the bony rim (fig. 2*B*, *1*), the glenoid lip separating with the capsule. In 2 of these cases there were tags of tissue and in 1 bone fragment free in the shoulder joint. The bony rim was worn down considerably in 1 instance. It is for these two types that a method of attaching the capsule to bone must be designed. In 6 cases there were tears above the glenoid lip (fig. 2*C*). This type does not need sutures into the bone. The glenoid lip is tough enough to contain the sutures. In the remaining cases tears were present within the structure of the capsule.

The history in all cases is similar except in the details of acquisition. Hence it is not deemed necessary to copy all the records. The following cases illustrate a point:

C. F., 20 years of age, was struck in the back of the arm while playing football. He experienced pain in the shoulder, but he finished the game. The shoulder felt weak after use and also became sore. On examination there was tenderness over the shoulder anteriorly "deep in". Physical therapy and exercise did not relieve him of his complaint. A diagnosis of tear in the anterior capsule of the shoulder was made and the import explained to the patient. One year later, or eighteen months after the injury, he began having dislocations. At operation the capsule and the glenoid lip were found separated from the bony rim. This part of the capsule can be slightly torn and later give increasing trouble just as in tears of the rotator cuff superiorly, or the so-called supraspinatus tendon lesions.

J. P., aged 25, aimed a heavy blow at his opponent while fighting, but missed. He immediately experienced a severe pain in the shoulder. He received no immediate treatment. The condition existed for four years before he sought treatment after having had thirteen dislocations. At operation there was a 3 cm. tear of the anterior capsule just above the glenoid lip (fig. 2*C*). The free end of the capsule was sewed to the glenoid lip. There were 2 other cases in which there was no direct driving blow into the shoulder, as Bankart explained.

R. M., aged 26, injured one shoulder in a football game in 1937. The shoulder dislocated twice a week or whenever the arm was raised above gunstock level. A Nicola operation was done in 1940, which cut the number of dislocations by one half. In 1943 a Henderson operation was done, which decreased the dislocations to one a month. Early in 1946 the acromial process was resected, but still the shoulder dislocated. At operation the capsule was found torn between the inferior

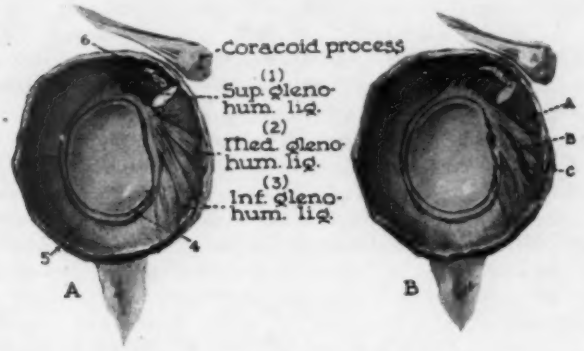


FIG. 1.—Looking into the shoulder joint after the head of the humerus has been enucleated (5, capsule; 4 labrum glenoidale or glenoid ligament; 6 biceps tendon). *A*, tear above the medial glenohumeral ligament; *B*, tear between medial and inferior glenohumeral ligaments, *C*, glenoid lip and capsule torn from the bone rim of the glenoid.

This figure was used in a previous article.[10]

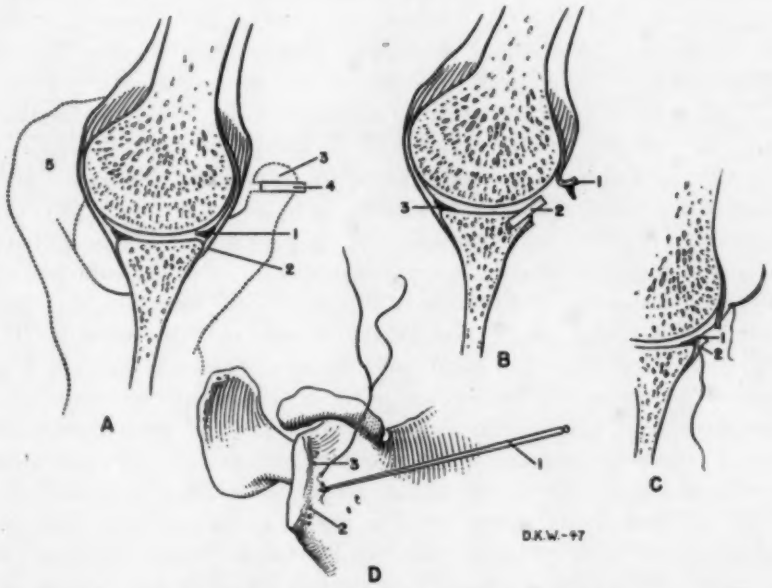


FIG. 2.—*A*, (1) labrum glenoidale (glenoid lip) detached from the bony rim, (2) where stripping of capsule may take place (this stripping often goes beyond the point where drill holes are made in *D*), (3) site of cutting tip of coracoid, (4) section which is taken for a bone graft. (5) acromial process. *B*, (1) torn capsule with glenoid lip (it seldom is as intact as this drawing shows it to be) at the anterior surface of the shoulder joint, (2) the bone graft, (3) intact glenoid lip posteriorly. *C*, (1) tear in capsule just above glenoid lip, (2) glenoid lip. *D*, (1) crochet needle, (2-3) area of anterior glenoid where the glenoid lip is worn away or torn and bone may be worn down.

and middle glenohumeral ligaments, and the glenoid lip was torn from the glenoid rim. The bony rim was worn round and deep. Here the capsule was sutured to the bone, and a bone graft was planted into the edge of the glenoid rim. It is nine months since this operation, and there have been no dislocations. Someone has remarked that the amount of scar tissue produced at operation is more important than the type of operative procedure used. If the bony rim is worn down, it probably is best not to depend entirely on procedures involving soft tissue. In cases in which the glenoid lip is badly frayed, a bone graft should also be done. In 6 other cases a Nicola operation was performed, in 3 a Henderson, in 1 an Ehrlich-Clairmont, and in 1 a Bankart. In this case the repaired capsule was intact but there was no glenoid lip. In fairness to the other operative procedures it must be mentioned that at one of the Nicola operations exploration showed no evidence that the biceps tendon had been cut or that a bone tunnel had been made. There has been a recurrence in 1 of my cases. Five years after repair was carried out, a stout and muscular person, while on army duty, was out on a drunken spree and injured the repaired shoulder. The operating surgeon informed me that the capsule was badly torn.

### OPERATIVE TECHNIC

The approach to the region is the so-called anterior approach to the shoulder joint except that the incision should extend up to the clavicle. The details of this are well illustrated in a previous article.[10] After the deltoid and pectoralis major muscles have been separated, the coracoid process comes into view. I recommend freeing the conjoined tendon with a tip of the coracoid process rather than retracting it. This gives a wider exposure. Too much bone should not be taken with the muscles or the stump will be short and cause difficulty in closing. Also this is a good source for obtaining the bone graft. Usually a section about three sixteenths of an inch (0.46 cm.) wide is taken. The ensuing shortening of this process has not been found to be detrimental. With the arm in moderate outward rotation, the subscapularis is easily identified. When cutting this muscle I leave most of the tendinous portion of the muscle with the capsule. This is sewed to the bony rim or glenoid lip as a reenforcement when the capsule is resutured. There has been no difficulty encountered in resuturing the subscapularis muscle. The capsule then comes into view. After separation of the loose connective tissue the pathologic process can be evaluated and proper repair done. There is no difficulty if the glenoid lip is intact. If it is not, holes must be drilled into the bone. Sir Robert Jones stated in connection with operations on the knees that sutures should not project through the capsule into the joint. The same rule might well be followed here. Instead of inserting the sutures across the edge of the glenoid rim, I make three pairs of holes parallel to the articular margin. Each of the holes of a pair is drilled at an angle so that they meet under the surface. An ordinary drill is effective. An instrument not unlike a crochet hook is introduced into one hole and rotated while a silk suture is fed or

pushed into the adjoining hole. It takes but an instant to snag the suture with the hook if enough suture has been fed into the hole and if the two holes meet under the surface. To this suture is tied a longer double suture; when this is pulled through and centered in the holes and cut at the knot with the single suture there are two sutures in this tunnel. Three pairs of holes are usually made, giving six sutures with which to tie the capsule and the tendon stump firmly to the bone. The bone graft, when used, is put on the joint side of the capsular sutures.

The sutures in the subscapularis muscle are put in after the fashion of the Koch tendon sutures. The coracoid stump is held in place with one silk suture through an effectively placed drill hole.

The arm is dressed in a Velpeau bandage for ten days. A sling is worn for a short period. There should be no outward rotation or hyperabduction for three months. Patients have about 10 to 15 degrees of permanent limitation of outward rotation. This seems to be no handicap.

SUMMARY

In all cases of recurring dislocated shoulder there were tears in the capsule anteriorly. The Bankart procedure attempts to prevent dislocations by repairing this defect. The defect at first may be small. Under the stress of use it gradually gets larger until it permits recurrent dislocations.

# COMPLICATIONS OF GASTROENTEROSTOMY

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GASTROENTEROSTOMY in the treatment of intractable duodenal ulcer has had a varied career. Its initial popularity was gradually dissipated when the true incidence of its complications was demonstrated and subtotal gastric resection became the operation of choice for the majority of these patients. The pendulum now swings back with gastroenterostomy being advocated as an adjunct to vagotomy in those cases in which some degree of pyloric obstruction exists preoperatively (Dragstedt[1]). It is to be expected that the incidence of gastrojejunal ulcer will prove to be negligible due to the low levels of gastric acidity produced by the associated vagotomy. Whether difficulties in motility and gastric emptying will lower the efficiency of this combined procedure only follow-up studies can determine.

There is, however, a type of patient in whom gastroenterostomy in itself has always yielded good results, in whom vagotomy is not required and in whom subtotal gastric resection is not indicated. Such a patient is one past middle age with a lowered tension of living. Permanent pyloric obstruction is present, the result of scar formation about a chronic duodenal ulcer associated with normal or subnormal gastric acidity. Ogilvie[2] states that chronic obstructing duodenal ulcers lead to atrophic gastritis with permanent lowering of the gastric acidity. An additional factor of safety exists if the patient is a woman, as the incidence of gastrojejunal ulcer after gastroenterostomy is only one seventh that of a man.

Gastroenterostomy is not indicated in acute perforation of duodenal ulcer. Guthrie and Sharer[3] in analyzing 84 such cases found that in only 1 out of 5 did sufficient duodenal obstruction de-

1. Dragstedt, L. R.: Vagotomy for Gastroduodenal Ulcer, Ann. Surg. **122**:973-989 (Dec.) 1945.

2. Ogilvie, W. H.: Place of Surgery in Treatment of Peptic Ulcer, Lancet **1**:419-424 (Feb. 23) 1935.

3. Guthrie, D., and Sharer, R. F.: Permanence of Cure Following Ruptured Duodenal Ulcer, J. A. M. A. **107**:1018-1023 (Sept. 26) 1936.

velop to require a gastroenterostomy at a later date. Wakeley[4] reports similar findings. The procedure is indicated, however, in subacute perforation in which healing of the ulcer and resolution of the inflammatory mass will usually follow. Vagotomy may prove to be a useful adjunct in these cases.

If the foregoing factors are ignored, however, complications frequently arise, illustrated by the following cases.

CASE 1.—*Persistent Vomiting.*—A white woman, aged 34, was admitted to the hospital on Jan. 27, 1946. Gastroenterostomy had been performed elsewhere in 1936 for duodenal ulcer. She improved until 1941, when periodic vomiting and epigastric distress appeared associated with symptoms of colitis which resisted medical management. The patient lost weight and became moderately addicted to barbiturates. Roentgen studies indicated a possible prepyloric ulcer, but no evidence of ulcer at this site or in the stoma could be seen on gastroscopic examination.

The gastroenterostomy loop was taken down, restoring normal gastrointestinal continuity. Evidence of ulcer was not found.

The patient returned to the hospital a few weeks after discharge with moderate gastric retention, but one week later the stomach was seen by fluoroscopy to empty rapidly and she was discharged on ulcer management. She has since gained 18 pounds (8.2 Kg.) and has returned to work. She has been relatively free of abdominal distress.

*Comment.*—Gastroenterostomy is not indicated in young girls with unstable nervous systems even though stomal ulcers are unlikely to develop. Such patients will respond to medical and psychiatric management. The vomiting in this patient may have been the result of a vicious circle through the open pylorus and jejunal stoma.

CASE 2.—*Gastrojejunal Ulcer with Hemorrhages and Acute Perforation.*—A white man, aged 76, was admitted to the hospital in September 1946. Gastroenterostomy had been performed fifteen years before for duodenal ulcer, with relief for two years. He was hospitalized ten years before the present admission for ulcer distress and three years before this admission for gastric hemorrhage, which subsided only to recur several times.

The present admission occurred four hours after the sudden onset at midnight of excruciating epigastric pain associated with boardlike rigidity, one emesis, a temperature of 99 F., a white cell count of 18,000, polymorphonuclears 88 per cent, and a normal urine. Continuous gastric aspiration, intramuscular administration of 50,000 cc. of penicillin every three hours and intravenous injection of fluids were immediately instituted. A roentgenorgram of the abdomen revealed air under both leaves of the diaphragm and possibly pneumonitis of the right lung (fig. 1). The patient's pain and rigidity had meanwhile improved so much that operation was deferred, and recovery was uneventful. An ulcer regimen was started on the third day, and roentgenograms of the stomach after administration of barium sulfate were taken within two weeks. The duodenum filled normally, and stomal ulcer could not be demonstrated. On strict ulcer management the patient had had no bleeding or further distress for six months and has returned to work.

4. Wakeley, C. P. G.: Late Results of Perforated Peptic Ulcer, Lancet **1**:11-12 (Jan. 1) 1944.

*Comment.*—Hermon Taylor[5] reports 28 perforated peptic ulcers treated by gastric aspiration with only four deaths, three of which were not related to the conservative method of treatment. When surgical procedures are hazardous because of the patient's age and associated complications, a few hours' trial of suction may be indicated with the patient lying on his left side. Administration of penicillin and intravenous injection of fluids should be started and the condition of the abdomen noted every hour. In many instances the leakage will be stopped as effectually by this method as by operation.

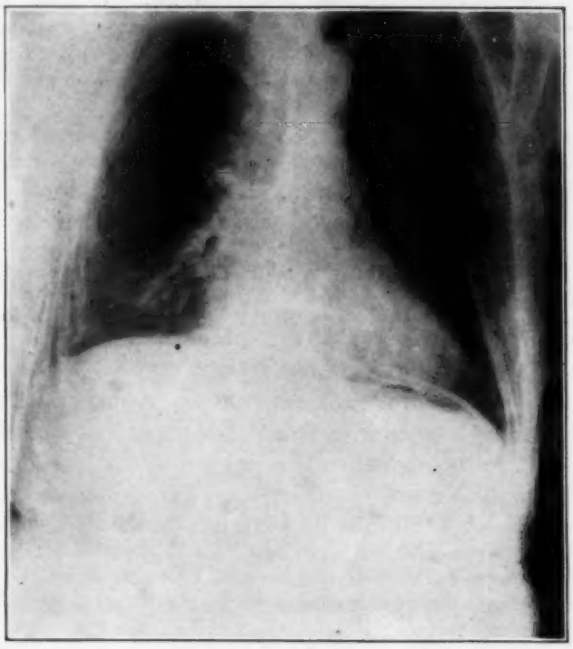

FIG. 1.—Air is present beneath the diaphragm bilaterally indicating a perforated viscus.

If further episodes of bleeding occur in this patient, vagotomy must be considered.

CASE 3.—*Gastrojejunal Ulcer with Perforation into the Mesocolon.*—A white man, aged 32, was admitted to the hospital in June 1940. Gastroenterostomy for obstructing duodenal ulcer had been performed in 1927. In 1938 ulcer pain recurred, with the recent development of nausea, vomiting and pain in the back. Gastric analysis revealed 60 total and 40 points of free hydrochloric acid. Roentgen examination showed that barium emptied freely through the pylorus. At the anastomotic site barium entered a false cavity in the transverse mesocolon.

5, Taylor, H.: Perforated Peptic Ulcer Treated Without Operation, Lancet **2**:441-444 (Sept. 28) 1946.

On elevating the transverse colon, a crack appeared in a friable area of the mesocolon, opening into a cavity 4 cm. in diameter continuous with the stomach and duodenum (fig. 2). The short proximal jejunal loop was thickened and hyperemic back to the duodenum and indurated masses were present in its mesentery. The gastroenterostomy loop was taken down, the diseased jejunum resected, and an end to end jejunal anastomosis performed between the normal distal end and the dilated thickened proximal end at the ligament of Treitz (fig. 3) Gastric resection was postponed to a second stage because it was feared temporary obstruction from edema might develop at the jejunal anastomosis. With the stomach resected such an obstruction would back up bile and pancreatic juice in a closed loop causing leakage at the jejunal anastomosis, leakage at the duodenal stump or pancreatitis.

Recovery was uneventful except for some ulcer distress the second week. On the thirteenth day distress at night was relieved by aspiration of a small amount of

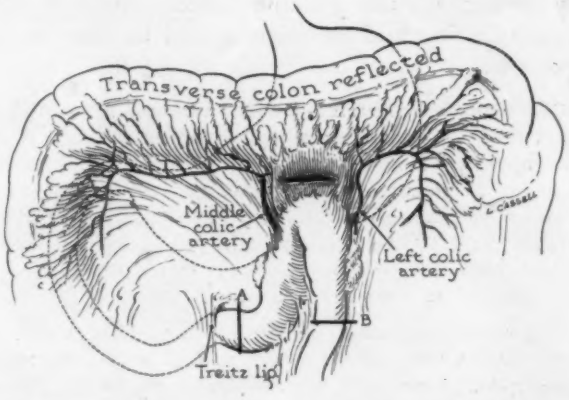


FIG. 2.—Crack extending into abscess cavity in transverse mesocolon continuous with jejunal ulcer. Jejunum resected between *A* and *B* with end to end anastomosis.

gastric juice with a total acid of 94 points and a free acid of 59 points. Little distress appeared thereafter, the patient being discharged on the seventeenth day to continue hourly feedings of milk and cream, three accessory feedings, and neutralization with aluminum hydroxide. The patient was readmitted in five days because of recurrent ulcer distress, an exsanguinating hemorrhage developed the same day with exacerbation of the bleeding and death that night. A blood bank was not available for the massive transfusions required to make operation feasible.

At autopsy, the duodenojejunal anastomosis was seen to be healed without constriction and a healed scar was present in the stomach. On the posterior wall of the duodenum was an acute ulcer, 2 cm. in diameter, penetrating into an aneurysmal dilatation of the superior pancreaticoduodenal artery.

*Comment.*—Gastrojejunal ulcer in this patient could almost be predicted because the original operation was performed on a 19 year old youth with high gastric acidity and a patent pylorus. Removal of the anastomosis elevated the gastric acidity 34 points. The exsanguination of this 32 year old man in his first hemorrhage while

on ulcer management is unusual. Blackford and Williams,[6] reporting all fatalities in Seattle over a five year period from peptic ulcer hemorrhage, found that 78 per cent of the patients died in their first hemorrhage, but that 97 per cent were over 45 years of age. They stated that they knew of no surgical experience that justifies emergency operation in younger patients for hemorrhage due to ulcer even with prostrating bleedings. Allen and Benedict,[7] also Welch and Yunich,[8] stated that death is rare under the age of 50. Exsanguination in this young patient was the result of the aneurysmal dilatation, but the case illustrates the speed with which a duodenal ulcer may be reactivated. In the surgical treatment of gastrojejunal ulcer, vagotomy may prove to be the operation of choice but if the anastomosed loop is merely unhooked and a high gastric resection not immediately performed, the patient should remain in the hospital under close supervision and resection should be done as soon as his condition permits.

CASE 4.—*Gastrojejunocolic Fistula.*—A white man aged 51, was admitted to the hospital in April 1940. Gastroenterostomy was performed elsewhere in 1935 without relief of ulcer symptoms. There was a history of vomiting, foul eructations, marked diarrhea and loss of 23 pounds (10.4 Kg.) over the past four months. Persistent pain in the epigastrium radiated to the back. Examination revealed an incisional hernia, red blood cells 4,500,000, hemoglobin 75 per cent and normal urine. No evidence of avitaminosis was present. The eight to ten stools passed daily were bulky and fatty but contained no undigested food.

Barium meal reached the cecum in three to four minutes, and the stomach was almost empty in two hours. Only a small amount entered the transverse colon (fig. 4). In twenty-four hours more barium was present in the stomach than at five hours, having reentered from the colon (fig. 5). A barium enema passed freely through the fistula into the jejunum and thence into the stomach (fig. 6).

The patient was prepared for operation by restoring his vitamins, chlorides, proteins and tissue fluids. A transfusion was given the day before operation and one during the operation. The diarrhea resisted all attempts at management. The colon and connected stomach and jejunum were cleansed by enemas the evening before the operation and no food was given by mouth after the preceding noon meal.

A left paramedian incision was made. The lesser curvature of the stomach was freed from the liver and the gastrohepatic omentum divided. With the left hand behind the stomach through this opening, the gastrocolic omentum was sectioned

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6. Blackford, J. M., and Williams, R. H.: Fatal Hemorrhage from Peptic Ulcer; One Hundred Sixteen Cases Collected from Vital Statistics of Seattle During the Years 1935-1939, Inclusive, J. A. M. A. **115**:1774-1776 (Nov. 23) 1940.

7. Allen, A. W., and Benedict, E. B.: Acute Massive Hemorrhage from Duodenal Ulcer, Ann. Surg. **98**:736-749 (Oct.) 1933.

8. Welch, C. S., and Yunich, A. M.: Problem for Surgery in Treatment of Massive Hemorrhage of Ulcer Origin, Surg., Gynec. and Obst. **70**:662-665 (March) 1940.

on either side of the fistula safeguarding the middle colic artery. Rubber-covered clamps were placed on the colon and jejunal limbs, the colon cut free and the

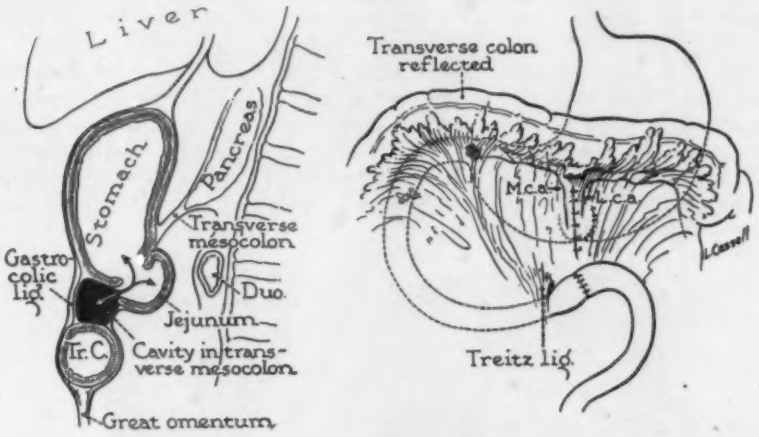


FIG. 3.—Cross section of abscess cavity showing continuity with stomach and jejunum. Completed operation.

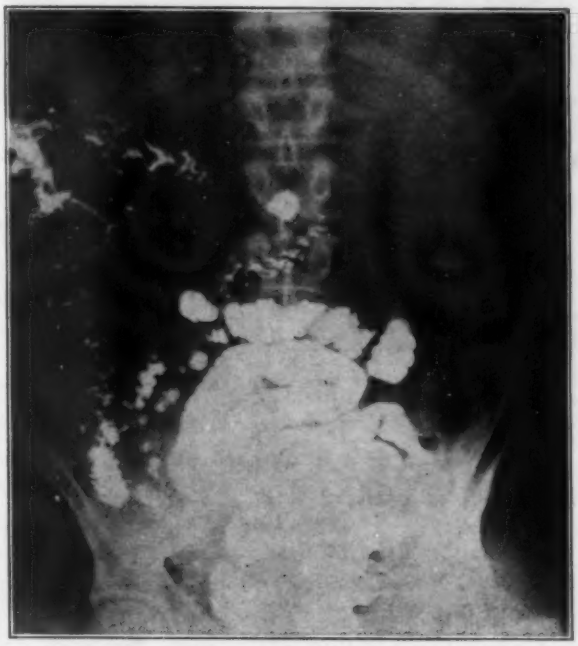

FIG. 4.—Three hour film showing barium primarily in small bowel.

stomach sucked dry. The defect in the colon was closed transversely and soiled gloves, drapes and instruments were discarded. The jejunum was cut free, three

quarters of the stomach resected and the long defect in the jejunum united to the gastric stump as in the Polya operation. The proximal jejunum was transplanted above the transverse mesocolon in such a manner that the defect in the mesocolon need be closed about the descending loop only (fig. 7) and traction avoided on the proximal loop.

Recovery was uneventful, gastric aspiration being employed for forty-eight hours. One month later the patient had gained 15 pounds (6.8 Kg.) and was symptom free. Gastroscopic examination revealed a mild hypertrophic gastritis. Seven years later, the patient has gained 35 pounds (15.9 Kg.), is symptom free, and is actively at work. He has neglected his diet and drinks whisky moderately. A hypertrophic gastritis is present, as shown by roentgen ray (fig. 8) and by gastroscopic examination.

FIG. 5.—Twenty-four hour film showing barium reentering the stomach from the transverse colon.

*Comment.*—This case is typical of the majority of gastrojejunocolic fistulas in that the stomach empties primarily into the jejunum, the contents passing rapidly down to the cecum and up the ascending colon, a portion reentering the stomach, to again descend the small bowel. This vicious circle so irritates the gastrointestinal tract that rapid peristalsis occurs, resulting in an intractable diarrhea which seriously impairs digestion and absorption.

Pfeiffer[9] recognized the nature of this process and suggested a

9. Pfeiffer, D. B.: Surgical Treatment of Gastrojejunocolic Fistula, Surg., Gynec. & Obst. **72**:282-289 (Feb.) 1941.

preliminary loop colostomy in the ascending colon such that fecal matter would not reach the fistula to reenter the stomach. Peristalsis,

FIG. 6.—Barium entering the jejunum and stomach after a barium enema.

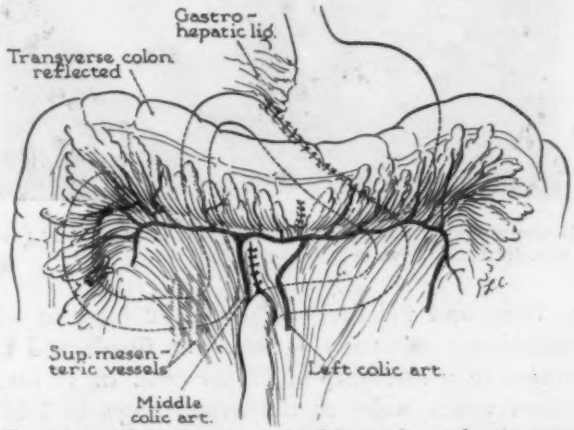


FIG. 7.—Transplantation of the proximal loop above the transverse mesocolon to avoid traction. Closure of the mesocolon about descending loop only.

digestion and absorption returned to normal, with great improvement in the patient's condition. Pfeiffer reports 15 cases, with op-

eration by various surgeons, in which preliminary colostomy was performed. Two patients did not improve because the stomach emptied primarily into the transverse colon and the contents discharged from the upper loop of the colostomy. One improved after the upper loop was plugged. A second stage excision of the fistula with or without subtotal gastric resection was performed with only one death. A third stage closure of the colostomy was necessary.

FIG. 8.—Hypertrophic gastritis present seven years after subtotal gastric resection for gastrojejunocolic fistula. No evidence of ulcer.

Atwater, Butt, and Priestley[10] reported 40 cases in which treatment by preliminary colostomy between the fistula and the hepatic flexture resulted in a mortality of 27 per cent. In 17 cases subtotal gastric resection was included at the second stage, in 1 of which recurrent ulcer subsequently developed. In the remaining cases gastro-

10. Atwater, J. S.; Butt, H. R., and Priestley, J. T.: Gastrojejunocolic Fistulae, with Special Reference to Associated Nutritional Deficiencies and Certain Surgical Aspects, Ann. Surg. **117**:414-426 (March) 1943.

intestinal continuity was restored omitting gastric resection, in 9 of which recurrent ulcer developed.

Marshall[11] reported 14 cases in which a two stage procedure was employed uniting the terminal ileum to the descending colon at the first stage. This eliminated fecal contamination of the stomach without soiling the abdominal skin by colostomy, and 2 patients were so improved that the second stage was unnecessary. Resection of the ascending colon, transverse colon and three fourths of the stomach was performed at a second stage in 12 patients, with only one death.

It would be of interest to determine if oral administration of one of the insoluble sulfonamide drugs would control the diarrhea in these cases by reducing the bacterial flora. If such were the case, these patients could perhaps be improved to the point where a one stage subtotal gastric resection could be performed without excessive mortality.

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11. Marshall, S. F.: Plan for Surgical Management of Gastrojejunocolic Fistula, Ann. Surg. **121**:620-633 (May) 1945.

# TOPICAL USE OF STREPTOMYCIN IN PERITONITIS

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AND

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THE TOPICAL USE of streptomycin in peritonitis should have a definite place in surgery either alone or in combination with supporting antibacterial agents. The exact limits of this place have not as yet been determined, and this communication, which is a preliminary report, is an attempt at definition.

The systemic administration of streptomycin in doses of 3 or 4 Gm. daily achieves blood concentrations of 20 to 25 units per cubic centimeter of serum. [1]The amount of the drug tolerated by the various species of gram-negative rods found in the intestine varies widely but may be as much as 250 units per cubic centimeter or more. The concentration of streptomycin in the peritoneal cavity of necessity is always less than that in the blood, and in cases of long-standing disease in which there is an impermeable abscess wall systemic administration per se is likely to be totally inadequate.

We therefore decided to investigate the topical use of streptomycin in selected cases of localized infections of the peritoneal cavity. Bacteriologic cultures were made before and during its application. It should not be necessary to show the need for close cooperation between the clinical bacteriologist and the surgeon; it should be as close, in fact, as that already existing between the surgeon and the pathologist in the treatment of tumors. It has been noted with some concern, however, that there is a widespread tendency to use heavily increasing doses of penicillin as a panacea without knowledge of the nature of the infection and regardless of whether the organisms are

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Read at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

1. Heilman, D. H., and others: Streptomycin: Absorption, Diffusion, Excretion and Toxicity, Am. J. M. Sc. **210**:576, 1945.

susceptible to penicillin or not. The habit of instituting antibacterial therapy and of determining the etiologic agent only on the evidence of failure is reprehensible at all times, but it is particularly so in the case of streptomycin. The well recognized risk of inducing resistance to the drug by inadequate initial therapy demands properly delineated indications for its exhibition.

There is nothing in the literature on the use of streptomycin topically applied in the peritoneal cavity. Keefer[2] mentioned the method but gave no details, and he confined his remarks to other modes of administration used in the cases cited in his papers.

It has been our practice, with due consideration of the factors of absorption and dilution in preexisting exudates, to instil streptomycin in 1 Gm. doses daily. These doses have been well tolerated and have given rise to no complications.

We are cognizant of the fact that topical applications as low as 200 units per cubic centimeter have been advocated, but we consider this entirely inconsistant with the known tolerance on the part of bacteria. Indeed, even our own much larger doses have not regularly achieved obvious bacteriostasis.

This dose seems high, but we find that 10,000 units of streptomycin per cubic centimeter does not disturb the action of the delicate ciliary epithelium. The use, therefore, of 1,000,000 units for abscesses or for general peritonitis in order to allow for variable dilutions does not seem excessive.

In order to exemplify these points, the following abstracted case histories, with the accompanying charts, are included. They illustrate the importance of adequate drainage, selective chemotherapy and careful timing in the treatment of infections in the peritoneal cavity.

CASE 1.—L. F. had a perforated common bile duct causing subphrenic abscess. There was a history of nonfunctioning gallbladder for four years, with many attacks of pain in the right side of the hypochondrium. Operation revealed a dilated common bile duct into which 2 fingers could be introduced easily and which was filled with over fifteen exceedingly large calculi, some of which were larger than marbles, and one small stone plugging the cystic duct.

Another stone near the origin of the common bile duct had ulcerated through the wall, causing a perforation. The ensuing convalescence was stormy (chart 1*A*), and two months later there was a ramifying abscess larger than a grapefruit. The prognosis was almost hopeless.

Penicillin had been used unsuccessfully. The explanation for its failure lay in the continued culture of Bacillus coli, which was producing penicillinase (see table).

Streptomycin in 1 Gm. doses daily was instilled into the abscess on four occasions, resulting in the disappearance of B. coli. The gram-positive organisms persisted.

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2. Keefer, C. S.; Streptomycin in the Treatment of Infections—A Report of One Thousand Cases, Committee on Chemotherapeutics and Other Agents, National Research Council, J.A.M.A. **132**:4 (Sept. 7); 78 (Sept. 14) 1946.

*Bacteriologic Table*

| | |
|---|---|
| **Case 1** | |
| Before streptomycin | Bacillus coli, producing penicillinase |
| After penicillin | Staphylococcus pyogenes, which did not become penicillin resistant |
| After streptomycin | Staphylococcus pyogenes |
| After penicillin (locally) | Sterile |
| **Case 2** | |
| Before streptomycin | Hemophilus influenzae in varying numbers, but usually in large amounts accompanied with occasional other organisms of both respiratory and intestinal origin, i. e., B. coli, enterococci (Lanceford B. and D.), streptococci, pneumococci of type 13 |
| After streptomycin and penicillin | Sterile |
| **Case 3** | |
| Before streptomycin | Aerobacter aerogenes |
| After strepomycin | Aerobacter aerogenes |
| **Case 4** | |
| Before streptomycin | B. coli |
| After strepomycin | Sterile |
| **Case 5** | |
| Before streptomycin | Aerobacter aerogenes |
| After streptomycin | Sterile |
| **Case 6** | |
| Before streptomycin | Copious growth of mixed gram-negative intestinal rods comprising B. coli, A. aerogenes, Proteus and Pyocyaneus |
| After streptomycin | Organisms persisting |

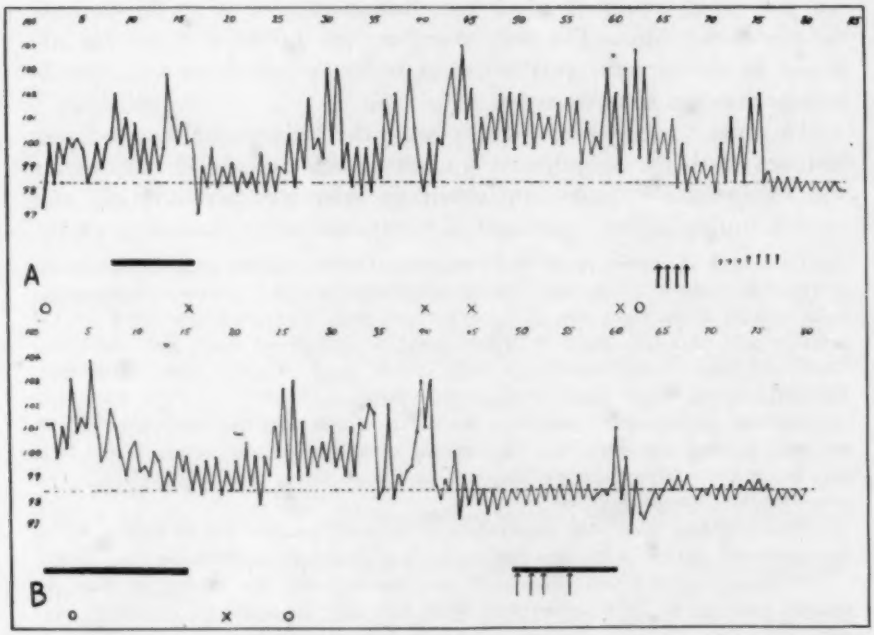


Chart 1.—*A*, temperature chart in days in case 1. The horizontal bar indicates that 25,000 units of penicillin was given every three hours, the vertical arrows that 1,000,000 units of streptomycin was instilled locally and the small vertical arrows that 25,000 to 50,000 units of penicillin was applied locally. *O* indicates operation and *X* radiographic examination. *B*, temperature chart in case 2.

Penicillin was then used locally. There was prompt disappearance of the staphylococcic organisms, and a gratifying clinical cure resulted. There has been no relapse in two years.

CASE 2.—In this case a subphrenic abscess followed a perforated gastric ulcer, which did not respond to the use of penicillin and surgical drainage. As the organisms were susceptible to streptomycin, 1 Gm. was instilled into the abscess cavity daily for four days.

The last dose of streptomycin in a volume of about 10 cc. could barely be placed in the cavity as it had shriveled to an extremely small size. The temperature became normal, and the patient has remained well since (chart 1*B*).

CASE 3.—The patient had a subphrenic abscess after perforation of a duodenal stump subsequent to partial gastrectomy. The abscess was drained, and three daily doses of streptomycin were instilled into it. Although the cavity shrank in size

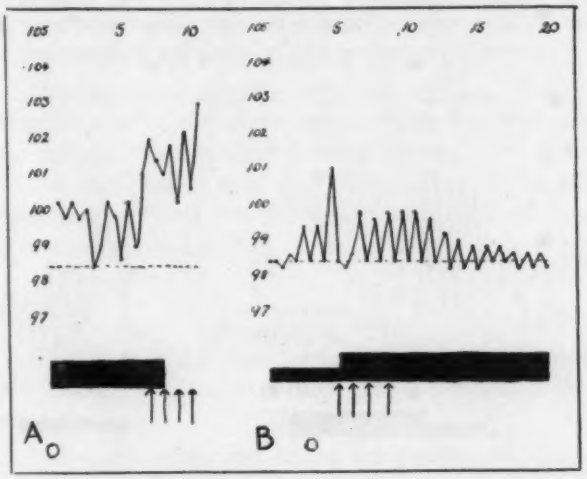


Chart 2.—*A*, temperature chart in days in case 3. The horizontal bar indicates that 25,000 to 100,000 units of penicillin was given every three hours and the vertical arrows that 1,000,000 units of streptomycin was given locally. *O* indicates operation. *B*, temperature chart in case 4. Horizontal bar here indicates administration of 50,000 units every three hours.

almost as quickly as in the 2 previous cases the organism remained throughout (table). Cure in this case must therefore be attributed to surgical intervention rather than to the antibiotic despite the simplicity of the organism in the abscess and the fact that it is among those more sensitive to streptomycin (chart 2*A*).

CASE 4.—A perforated appendix, with localized abscess in the pelvis and in the right lower part of the abdomen, was present in this case. One gram of streptomycin was instilled into the abscess, and a culture taken twenty-four hours later was sterile. The clinical condition improved steadily but somewhat more slowly than is usual in a case of acute appendictitis without perforation (chart 2*B*).

CASE 5.—J. B. had acute appendicitis with perforation and general peritonitis and acute pyelophlebitis. The patient was treated postoperatively with large doses of penicillin (100,000 units every two hours) for one week, with gradual deterioration. A culture was taken, which yielded mainly B. coli.

Streptomycin was instilled into the cavity daily in 1 Gm. doses, and after the second dose the culture remained sterile.

Toxicity increased to such an extent that the patient died of hepatic insufficiency on the tenth day postoperatively. In this case the use of streptomycin was successful, but the time factor was too great a handicap (chart 3*A*).

CASE 6.—The patient had ulcerative colitis with multiple polyposis and localized peritonitis. Hemicolectomy had been performed on the right side, and it was proposed to complete the operation. Two localized abscesses were discovered in the peritoneal cavity. The patient's condition was poor, but after consultation it was decided to proceed with the colectomy in spite of the presence of pus since subsequent removal would be extremely difficult in view of the friability of the intestines.

The operation was carried out, and he was given penicillin along with streptomycin which was instilled into the peritoneal cavity. (1 Gm. a day for four doses). In spite of the continued presence of intestinal organisms he made steady improvement and had no more than the usual reactionary temperature from such a major procedure. This seems to illustrate a case in which the judicious use of antibiotics

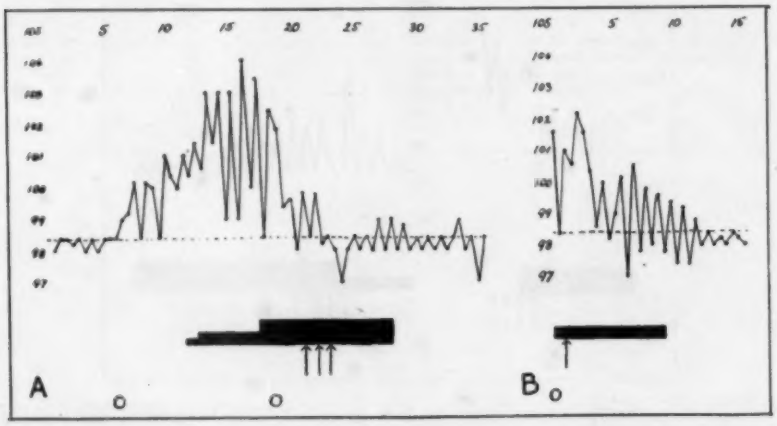


Chart 3.—*A*, temperature chart in days in case 5. The horizontal bar indicates that 100,000 units of penicillin was given every two hours and the vertical arrows that 1,000,000 units of streptomycin was given locally. *O* indicates operation. *B*, temperature chart in case 6. Horizontal bar here indicates that 50,000 to 100,000 units of penicillin was given every three hours.

allowed a radical operation to be performed by reducing the toxicity of the organisms, which, however, continued to grow.

This is comparable to the change which the use of the antibiotics made in the results of surgical treatment during the last war, in which the use of the sulfonamide drugs and penicillin, with delayed primary suture, gave such excellent results (chart 3 *B*).

In inflammatory processes streptomycin does not penetrate through the pyogenic membrane as well as penicillin. The concentration of the drug in the blood stream is of necessity limited by its toxicity, and it is much more toxic than penicillin. Systemic therapy alone is

therefore inadequate and should be supplemented by local application of the antibiotics to obtain satisfactory bacteriostatic levels.

Frequently enough the coliform organisms which may be found in the peritoneal cavity not only are not susceptible to the action of penicillin but may indeed destroy this substance as they elaborate penicillinase (case 1).

It is for this reason that streptomycin used either alone or in combination with penicillin might achieve considerable importance because of its effect on the penicillin-insensitive coliform bacteria.

We have not been impressed by its effect on the gram-positive bacteria which so frequently are components of infecting flora in peritonitis. Penicillin remains the drug of choice for such organisms despite the inference of Buggs and others.[3]

In view of the recognized amount of streptomycin tolerated by intestinal bacteria, which commonly runs as high as 250 units per cubic centimeter, it is necessary to establish concentrations of the drug in the infected tissues several times greater than those tolerated by the various organisms; this will allow for progressive absorption from the peritoneum and for the unknown factor of immediate dilution by the peritoneal fluid.

## SUMMARY

Case 1 illustrates the importance of the order and the correct timing of adequate surgical treatment in combination with the use of antibiotics.

In case 2 surgical treatment failed until streptomycin was used.

In case 3 streptomycin was not successful even though a single usually susceptible organism was present.

In case 4 a single dose was sufficient, and the patient herself felt improvement within twelve hours.

Case 5 illustrates failure in timing. The vicious cycle of toxemia was never broken.

In case 6 an extreme operation was performed on an exceedingly debilitated patient.

Merck & Co. supplied the streptomycin. Drs. Gavis Miller, A. Wilke, J. Armour and D. Webster permitted us to report their cases.

3. Buggs, C. W., and others: The in vitro Action of Streptomycin of Bacteria, J.A.M.A. 130:64 (Jan. 12) 1946.

# INTUSSUSCEPTION OF THE APPENDIX

CHARLES B. PUESTOW, M.D.

AND

WILLIAM E. LOOBY, M.D.

CHICAGO

THE FIRST REPORT in the literature on intussusception of the appendix was made by John McKidd in 1858.[1] Unfortunately his young patient died one month after he was first seen without having the benefit of surgical treatment. The exquisite pain which this youngster must have suffered is evidenced by the fact that in addition to morphine it was necessary to administer chloroform on several occasions prior to death. Since this report, similar cases have been reported on an average of 1 each year. Rarely has a correct preoperative diagnosis been arrived at, although certain characteristics of the disease are definite enough at least to warrant its inclusion in the differential diagnosis of surgical diseases of the abdomen.

The case being presented is of interest not only because of the pathologic changes found at operation but also because of the erroneous preoperative diagnosis arrived at after careful study by a competent roentgenologist and gastroscopist. A review of the literature will follow this presentation.

## REPORT OF A CASE

*First Admission.*—R. A., a Negro 51 years of age, was first admitted to the Veterans Administration Hospital, Hines, Ill., on July 19, 1937, complaining of a dull intermittent aching pain in the right side of his abdomen which began in the flank and radiated to an area near his umbilicus. This pain usually came on at night several hours after eating. Occasionally it was associated with nausea and

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From the Department of Surgery, University of Illinois College of Medicine and the Veterans Administration Hospital, Hines, Ill.

Read at the Fourth Annual Meeting of the Central Surgical Association, Chicago, Feb. 22, 1947.

1. McKidd, J.: Case of Invagination of the Coecum and Appendix, Edinburgh M. J. 4:793-796, 1859.

vomiting. These symptoms had existed for at least five or six years without variation, the pain being always on the right side of the abdomen. He reported a weight loss of 10 to 20 pounds (4.5 to 9 Kg.) in the preceding six months and chronic constipation for which he habitually took cathartics. There was no history of hematemesis or of blood in the stools. On one examination he mentioned having taken sodium bicarbonate frequently for relief of his abdonimnal distress. His past history was irrelevant. Physical examination was consistently noncontributory except that mild hypertension (160 systolic and 104 diastolic) and mild myopia of the left eye were revealed. Examination of the abdomen revealed no evidence of disease, and no masses were palpated

*Laboratory Examination.*—The red blood cell count was 4,750,000, with a hemoglobin content of 80 per cent. The white blood cell count was 5,800. Reactions to serologic tests and to tests of the spinal fluid were negative. Roentgenologic examination of the gastrointestinal tract revealed a constant deformity of the prepyloric area of the stomach, which was interpreted as a peptic ulcer. The colon and the gallbladder were reported to be normal.

*Course in the Hospital.*—In view of the roentgenologic evidence, a diagnosis of prepyloric, active peptic ulcer was made and the patient was placed on a Sippy regimen, which gave him some relief. He was finally discharged from the hospital on Nov. 23, 1937.

*Second Admission.*—The patient, now 60 years old, was readmitted to the hospital on May 21, 1946. At this time he gave a history of abdominal distress of twenty years' duration. He described his pain as a throbbing type of epigastric pain which he compared to a toothache and which appeared after nearly every meal or when he became excited or rushed. When he was quiet and his stomach was empty it was not present. It was also precipitated by the ingestion of cabbage, apples, pork or onions. He obtained relief by taking sodium bicarbonate, which produced vomiting followed by subsidence of pain. He reported a weight loss of 10 pounds (4.5 Kg.) in the preceding five months. The systemic inventory was otherwise entirely noncontributory.

*Physical Examination.*—The physical condition was essentially normal with the exception that mild hypertension (160 systolic and 108 diastolic), as noted on the previous admission, was observed.

*Laboratory Examination.*—The urinaiysis revealed no deviation from the normal. The reactions to Wassermann and Kahn tests were negative. The red blood cell count was 4,800,000, and the hemoglobin content was 95 per cent. The white blood cell count was 5,000. The coagulation time, the bleeding time and the plasma protein content were within normal limits. Repeated examinations of the gastric contents after a test meal revealed no free hydrochloric acid and an average total acidity of 18 points. Roentgenologic examinations of the stomach revealed a constant defect in the prepyloric area of the stomach, which was interpreted to indicate the existence of a gastric ulcer. No opinion as to the malignancy of the growth was expressed. It was noticed that the patient did not respond to an ulcer regimen but did as well on a general diet. In view of this observation and of the bizarre symptomatology, he was subjected to gastroscopy. The gastroscopist reported the clear visualization of a lesion in the prepyloric area of the stomach, which he interpreted to be an infiltrating carcinoma. The patient was immediately transferred to the surgical service, where an exploratory laparotomy was decided on.

*Operative Data.*—The abdomen was opened through an incision at the upper midline area. Exploration revealed a large and rather ptotic stomach, but no lesions could be seen or felt within it. The duodenum was easily visualized and

revealed no evidence of ulcer or other lesion. Exploration of the remainder of the abdomen revealed an intussusception of the appendix. About 2 inches (5.08 cm.) of appendix protruded from the end of the cecum, but a hemostat could be passed beside the appendix for about an inch (2.5 cm.) into a mass felt within the cecum. This mass within the cecum was about an inch in diameter and could not be reduced. The cecum was, therefore, opened and the mass within it exposed. As it

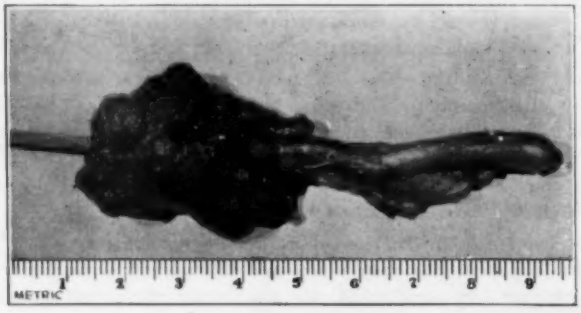


FIG. 1.—This photograph of the specimen removed at operation shows the appendix intussuscepted into the wall of the cecum. The chronic inflammation thus produced caused the wall to become thickened and explains the mass palpated in the cecum.

FIG. 2.—Photograph of the specimen after longitudinal sections discloses the marked hypertrophy of the cecal wall. The wall of the appendix is only slightly thickened. Intussusception of the appendix into the cecum is clearly shown.

appeared to be a benigm hypertrophy of the mucosa and the bowel wall and as a local excision would not encroach on the ileocecal valve, the mass and a small cuff of cecum were excised en masse. The opening in the cecum was then closed in layers.

Because of the positive roentgenologic and gastroscopic findings, it was deemed advisable to open the stomach in order to rule out definitely the diagnosis of gastric

lesion. A longitudinal incision 3 inches (7.6 cm.) in length was made in the mid-anterior wall of the stomach and careful exploration made of the entire gastric

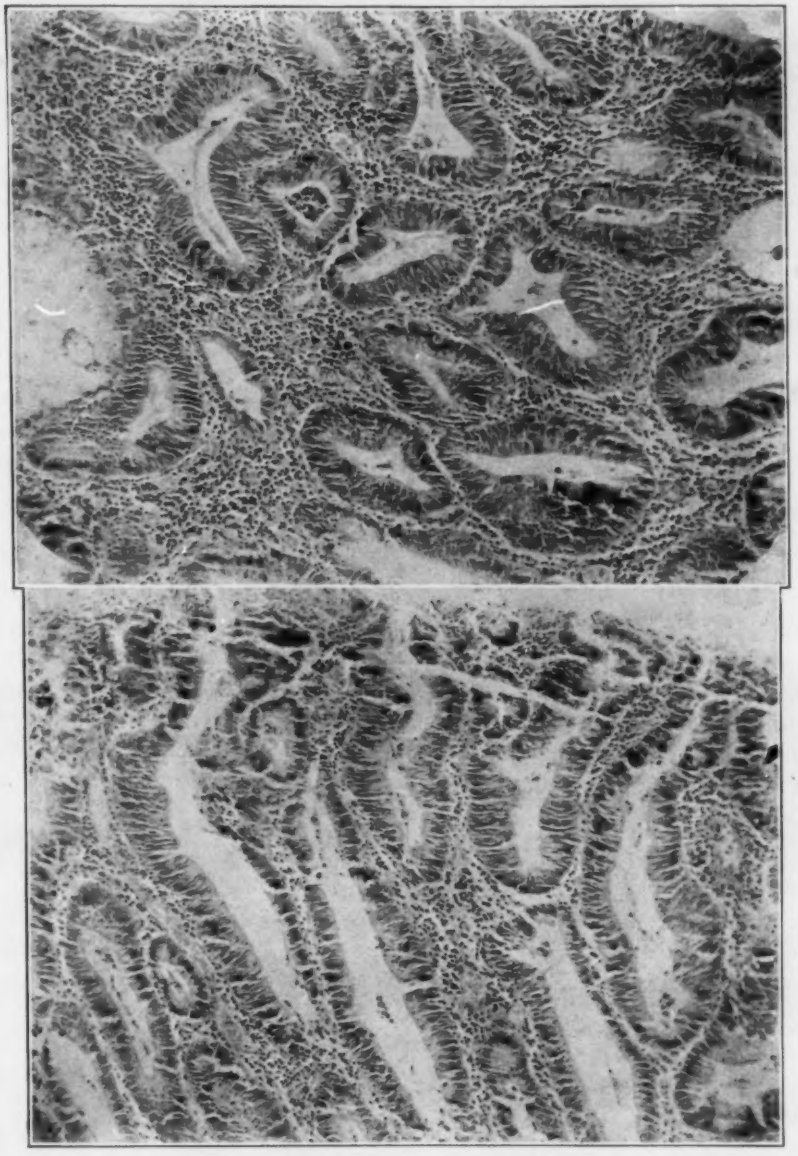

Fig. 3.—These photomicrographs of sections throughout the thickened wall of the cecum reveal only infiltration with lymphocytes and a small amount of fibrosis. There is no evidence of granulomatous change; × 250.

mucosa. Nothing abnormal was found. The stomach was then closed with an inner row of continuous sutures of surgical gut and an outer row of interrupted cotton sutures. The abdomen was closed in layers without drainage.

*Pathologic Report.*—The pathologist reported that the specimen consisted of an appendix which was invaginated into the cecum, thereby forming a mass 8 cm. in length. Grossly, the appendix showed no evidence of inflammation, and there was a definite line of demarcation between the wall of the appendix and the cecum. The microscopic examination disclosed an extensive diffuse fibrosis and a chronic inflammatory reaction. There was no evidence that this reaction was granulomatous. The diagnosis was (1) intussusception of the appendix into the cecum and (2) chronic inflammation of the appendix.

*Postoperative Course.*—The patient's postoperative course was uncomplicated, and he was discharged from the hospital on the twelfth postoperative day. At the time of his discharge he was on a regular diet, and he stated that all the abdominal distress from which he had suffered for twenty years had completely disappeared.

*Follow-up Examination.*—Five months after his discharge from the hospital the patient was reexamined. He was found to be symptom free and had returned to his usual work. He reported that the foods which had previously caused him distress could now be eaten with impunity, Roentgenologic studies revealed a normal prepyloric area from which the preexisting spasm had disappeared. He was again examined gastroscopically, and no evidence of carcinoma was observed.

## REVIEW OF THE LITERATURE

Since this condition was first reported by McKidd in 1858 less than 100 cases have been recorded in the literature. In 1941 McSwain[2] made a thorough analysis of 77 cases, and from the results of the survey certain conclusions can be drawn. He found the average age of the patients to be about 16 years, in contrast to an average age of 5 years noted by Moschowitz.[3] McSwain found that the earliest a patient had been operated on after the onset of symptoms was two hours and the longest delay was nine years. The patient reported on in this paper had symptoms for fifteen or twenty years prior to operation. During this period he had on various occasions been considered to be psychoneurotic.

The correct preoperative diagnosis of intussusception of the appendix has rarely been made. Spurney and Nyquist[4] in their study of 48 cases found the condition correctly diagnosed only once. In 41 cases the diagnosis was made at operation and in 5 at necropsy. In 1 case the diagnosis was made after passing of a sloughed-off appendix by rectum.

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2. McSwain, B.: Intussusception of Appendix; Review of the Literature and Report of a Case, South. M.J. **34**:263-271 (March) 1941.

3. Moschowitz, A. V.: Intussusception of Appendix, M. Rec. **78**:1087-1092 (Dec. 17) 1910.

4. Spurney, P. M., and Nyquist, D. M.: Intussusception of Appendix, Ohio State M. J. **18**:181-185 (March) 1922.

*Types.*—Szenes[5] found that the three types of intussusception of the appendix were: (1) invagination of the appendix into itself, (2) complete or partial invagination of the appendix into the cecum and (3) the inclusion of an intussuscepted appendix in a process involving intussusception of the ileum and colon. Fraser in an analysis of 82 cases found the first type present in 2 cases, the second in 44 cases and the third in 32 cases.

Anton and Weintrob[6] have collected 19 instances of nonspecific granuloma of the appendix, but intussusception did not occur in any of these. In the case reported here there were chronic inflammatory changes but no evidence of granulomatous change. It is probable that the inflammatory reaction was the result of the long period of intussusception. Numerous reports of carcinoid of the appendix are to be found in the literature, but in no instance did intussusception occur as a result of the tumor.

*Etiologic Factors.*—Wakely[7] suggested that the attempt of the appendix to extrude worms or fecoliths by hyperactive peristalsis might be the exciting cause of this condition in some cases. The presence of enlarged lymph glands which might act as a benign tumor in the production of the disease was also suggested by him. McDermott[8] found in anatomic studies of the appendix that it possessed a sphincter which was capable of becoming a firm mass when contracted, and he suggested that this condition associated with hyperactive peristalsis might cause the original invagination. In any event, it seems logical that the peristaltic action of the appendix may in some way be involved in the production of the condition. Fraser[9] found the cause of intussusception in 4 cases to be inversion of the appendical stump in a patient in whom the appendix had been removed. McSwain made a similar observation and questioned the advisability of invaginating the stump of the appendix after an appendectomy.

*Symptomatology.*—Most authors agree on the usual symptomatology found in this condition. Pain of a cramplike character usually occurred, with intervals of complete freedom from discomfort. In our case the throbbing pain comparable to a toothache hardly fits this description, and the patient repeatedly denied having exper-

5. Szenes, A.: Invagination of Appendix, Arch. f. klin. Chir. **119**:88-115, 1922.

6. Anton, J. I., and Weintrob, M.: Non-Specific Infective Granuloma of Appendix, U. S. Nav. M. Bull. **42**:1337-1349 (June) 1944.

7. Wakeley, C.P.G.: Intussusception of Appendix: Report of Two Cases, Lancet **2**:691-692 (Sept. 23) 1939.

8. MacDermott, E. N.: Appendiceo-Caecal Intussusception, Brit. M.J. **1**:793-794 (May 9) 1931.

9. Fraser, K.: Intussusception of Appendix, Brit. J. Surg. **31**:23-33 (July) 1943.

ienced any cramping pain. Nausea and vomiting were present in practically all the cases reported by McSwain and were prominent features in the case reported in this paper. Huddy[10] pointed out that the course of the disease must be divided into two stages: the first, long stage when the appendix itself is intussuscepted, and the second, shorter stage when colonic obstruction is produced by the appendix acting as a tumor and causing intussusception of the ileum and cecum into the colon. In the interpretion of the symptoms manifested by the patient these stages must be kept in mind. Intestinal obstruction as evidenced by obstipation occurs rarely, and the finding of blood in stools is not common even when ileocolic intussusception has taken place. McSwain mentioned that a palpable abdominal mass was present in 17 cases of intussusception of the appendix alone and in 26 patients with ileocolic intussusception. The intussusception was low enough in 6 cases to be felt rectally. He found only slight systemic reaction as evidenced by fever and leukocytosis. As a result of his analysis, McSwain listed the following points to be kept in mind in the diagnosis of intussusception of the appendix: (1) the history of more attacks than are usually observed in acute appendicitis; (2) the more definite cramplike pains simulating those of early intestinal obstruction; (3) the history of blood or mucus in the stools or their discovery on examination; (4) the presence of a mass in the right lower quadrant, and (5) less fere, increase in pulse rate and leukocytosis than would be expected in a patient with acute appendicitis. To these might be added the value of a roentgenogram of the colon to determine the presence of a filling defect.

### SURGICAL TREATMENT

Surgical treatment may be accomplished in several ways. The simplest method is to reduce the intussusception of the appendix and remove it by any of the accepted technics. Hinson[11] suggested that in cases in which the intussusception is not reducible an incision be made in the cecum and the appendix removed from within. His alternative method is to resect the part of the cecal wall which includes the base of the appendix. In cases in which an intussusception of the ileum and colon is present the cecum may be anchored to the lateral abdominal wall after reduction.

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10. Huddy, G. P. G.: Intussusception of Appendix, Brit. J. Surg. **14**:580-582 (April) 1927.

11. Hinson, A.: Invagination of Appendix, North Carolina M. J. **1**:358-359 (July) 1940.

**SUMMARY**

1. A case if intussusception of the appendix in an elderly Negro with symptoms dating back at least fifteen years is reported. Of interest is the fact that a preoperative diagnosis of carcinoma of the stomach by gastroscopy led to the exploratory laparotomy. During the long period of his illness, the patient had on various occasions been considered to be psychoneurotic. Five months after operation he had remained completely symptom free and was clinically well. Postoperative roentgenologic and gastroscopic studies failed to reveal evidences of gastric disease, which was suspected before operation.

2. A review of the literature is included in the report.

25 East Washington Street (Dr. Puestow).

# Surgical Clinics

## OBSTRUCTION OF THE COMMON DUCT BY STONE

WARREN H. COLE, M.D., AND STAFF
CHICAGO

DR. COLE: Before beginning our discussion today, I should like to call on Dr. Eastman to present the history and the findings in a case which we will use to illustrate various points.

DR. EASTMAN: The patient is a white woman, aged 37, who came to the outpatient clinic on June 26, 1946, complaining of itching, dark-colored urine and jaundice of eight days' duration.

Her past history is of significance. Thirteen years previously, at the age of 24 and during her first pregnancy, toxemia of pregnancy developed. She was delivered of a stillborn infant during the eighth month. In spite of this and of the sequela of hypertension, she became pregnant two years later and was delivered of a normal female infant (by cesarean section). In the years following until her appearance here in 1946 she complained of such symptoms of hypertension as headache and dizziness. These were controlled by medical management. For several years she also had intermittent attacks of severe pain low in the sternal area. This pain seemed to radiate to her back; occasionally it migrated to the epigastrium and was associated with nausea. It appeared to be precipitated by eating greasy foods and occasionally by emotional stress, and it was controlled by dietary management and by tincture of belladonna.

She appeared here early in 1946 because of headaches and dizziness. At this time her blood pressure was 213 systolic and 110 diastolic. She was given the usual diagnostic examination and was found to have grade 1 hypertension, with little evidence of organic damage. On the basis of the findings, a bilateral dorsal lumbar sympathectomy was advised. This was performed in two stages. Her postoperative recovery from each operation was good, and the results were excellent. Her headaches and dizziness were relieved, and the blood pressure has returned practically to normal.

The present illness began on June 18, 1946, with an attack of nausea and vomiting followed the next day by itching of the skin and by dark-colored urine. A day or two later her skin became yellow and her stools slightly acholic. At no time did she complain of pain. She had not had chills and did not believe fever had been present at any time.

Physical examination revealed her to be slightly icteric; the blood pressure was 140 systolic and 100 diastolic. The heart was slightly enlarged to the left. The liver was palpable 4 fingerbreadths below the right costal margin. At that time a diagnosis of homologous serum jaundice was made, largely because the

From the surgical conference, Department of Surgery, University of Illinois College of Medicine and the Illinois Research Hospital, Dec. 11, 1947.

jaundice was painless and was present in association with a history of three or four transfusions during two operations (sympathectomy in two stages) four months previously. The patient was placed on dietary management and asked to return later for observation. She was not seen again until six weeks later. During this interval diarrhea had developed and the stools had been acholic. The liver was still enlarged 6 or 7 cm. beyond the costal margin, but another indefinite mass on the edge of the liver, thought to be gallbladder, was now palpable. There was still no pain or tenderness; nevertheless a diagnosis of extrahepatic obstructive jaundice was made, largely because the stools had not become cholic. Celiotomy was performed by Dr. Cole on Aug. 19, 1946.

The anesthetic consisted of nitrous oxide and ether, with cyclopropane as the main agent; 40 units of curare was given for relaxation during the operation.

DR. COLE: Before we start the discussion of the obstruction of the common duct in this patient it would be pertinent to make one or two comments on her blood pressure, which originally varied between 210 and 220 mm. of mercury. After sympathectomy by Dr. de Takats, her symptoms have been completely relieved and her blood pressure has dropped to 140 systolic and 100 diastolic. You will recall that this patient complained of considerable epigastric pain for a few years, possibly caused by disease of the gallbladder, but had no pain from the obstruction of the common duct which developed after bilateral sympathectomy for hypertension. I think it would be appropriate to hear from Dr. de Takats at this time regarding the effects of the sympathectomy, particularly as related to its role in the absence of pain during the recent obstruction of the common duct.

DR. DE TAKATS: This case illustrates a number of important and interesting points. The patient's hypertension belongs to a group designated as grade 1, which responds fairly well to sympathectomy. If after the end of the first year there has been no true recurrence to the preoperative level, the pressures are apt to remain stable. Her systolic pressure has dropped to 130 or 140 and the diastolic pressure to 95 to 100 mm. of mercury. Such a diastolic pressure indicates some arteriosclerosis, which would be expected since the duration of her hypertension was more than ten years.

The other point of interest is one which Dr. Cole has already mentioned. In spite of the fact that for several years this patient had recurring attacks of pain in the epigastrium, with a sense of fulness and nausea related to eating certain types of food, these symptoms disappeared after the sympathectomy was performed. Moreover, when her common duct became obstructed she likewise had no pain. Dr. Cole can reaffirm that although jaundice produced by obstruction of the common duct by stone may not be accompanied with pain this symptom is present in about 80 per cent of cases. In regard to this patient, there was a history of painful attacks of biliary colic; it is reasonable to assume from recent experience that after the sympathectomy, undertaken to relieve hypertension, she now has a desensitized biliary tract and also a desensitized pancreas. This brings up the important point of whether patients, particularly those having complaints in the upper abdominal area of even a mild degree, should have their biliary tract visualized before splanchnic section is performed. The operation for hypertension may mask the symptoms of an acute condition in the upper abdominal area. The gallbladder may become gangrenous or a duodenal ulcer may perforate in patients who have undergone sympathectomy for hypertension. However it is proper to point out that splanchnic section affects only visceral sensitivity. There is still somatic pain originating from the peritoneum. The vagus is uncut, and therefore the sensation of nausea would still be present as a warning signal, as it was in this patient.

DR. COLE: As stated previously, the diagnosis made for this patient when she was first seen was homologous serum jaundice, because of the lack of pain and because of the youth of the patient. However when she was seen again a few weeks later the diagnosis of obstructive jaundice was obvious because of persistent acholic stools. Since the patient is here today, I think it would be informative to have her answer a few questions about her complaints. Mrs. X, how many attacks of pain in the upper part of the abdomen did you have before sympathectomy was performed?

PATIENT: I used to get them very frequently. Their occurrence would depend somewhat on the food I ate and on whether I was in an "upset" state. They would occur once or twice a week.

DR. COLE: How long would these attacks last?

PATIENT: I would be ill about thirty-six hours.

DR. COLE: Were you ever jaundiced previous to your attack in June 1946?

PATIENT: No, and after I had my operation for hypertension, there was no more pain in my abdomen.

DR. COLE: After the operation for hypertension, did you eat the same foods as before?

PATIENT: Yes, although I would get gas on my stomach, which, however, would pass off.

DR. COLE: Were you able to eat a greater variety of food after you underwent sympathectomy?

PATIENT: Yes.

DR. COLE: When jaundice developed, you had no pain?

PATIENT: No, sir.

STUDENT: How often is obstruction of the common duct by stone not associated with pain?

DR. COLE: In about 20 per cent of cases pain will be absent, but close questioning often will reveal some degree of epigastric pain during the first day or two after the onset of the obstruction.

STUDENT: How was the diagnosis of carcinoma of the head of the pancreas eliminated in this case?

DR COLE: The age of the patient (37 years) was probably the most valuable factor in eliminating the diagnosis of carcinoma of the head of the pancreas in this instance. The insidious onset of jaundice without pain as noted in this patient is identical with the early manifestations in 80 per cent of patients with carcinoma of the head of the pancreas, particularly since the stools remained acholic since onset. It is true that in most cases of obstruction of the common duct by stone the type of the stool will alternate from cholic to acholic in contrast to the constancy of acholic stool in carcinoma of the head of the pancreas.

We will now call on Dr. Eastman to read the operative report on this patient.

DR. EASTMAN: "A right paramedian incision was made. The gallbladder was greatly thickened and contained stones. There were numerous adhesions between the gallbladder, the duodenum and the colon. After separation of these adhesions, we palpated the common duct, which was enormously thickened and contained at least one large stone. The head of the pancreas was indurated but not much enlarged. We felt sure that this induration was inflammatory and not neoplastic. We aspirated the area which we thought was the common duct and obtained cloudy bile. We opened the duct and extracted two to three dozen small stones and one large stone about 2.5 cm. in diameter. The large stone was impacted in a cystic dilatation, with a valvelike fold of common duct on the anterior portion, which was bulging forward to block the common duct. We inserted a gallstone scoop above and below and obtained no stones above but many

additional stones distal to the opening. We incised the peritoneum around the duodenum to mobilize it in order to determine whether or not a probe could be inserted into the duodenum from the common duct. We were finally convinced that the sphincter of Oddi was open. We opened the lower end of the gallbladder to identify the location of the cystic duct, which was not clear because of great inflammation. We removed the gallbladder from below upward, leaving a short stump of cystic duct but closing it with surgical gut. A T tube was then inserted into the common duct, and the duct was closed around it with interrupted sutures of surgical gut. The bed of the gallbladder was then closed with continuous sutures. A Penrose drain was inserted down into Morison's pouch and the wound closed around the drain and the T tube."

DR. COLE: There were two rather unusual features noted at the operation. The largest stone in the common duct was firmly impacted in a cystic area, which had to be incised slightly before the stone could be removed. It is difficult indeed to explain how this impaction forms except by the presence of pressure and growth of the stone. The second unusual factor was the difficulty encountered in inserting a probe through the sphincter of Oddi into the lumen of the duodenum.

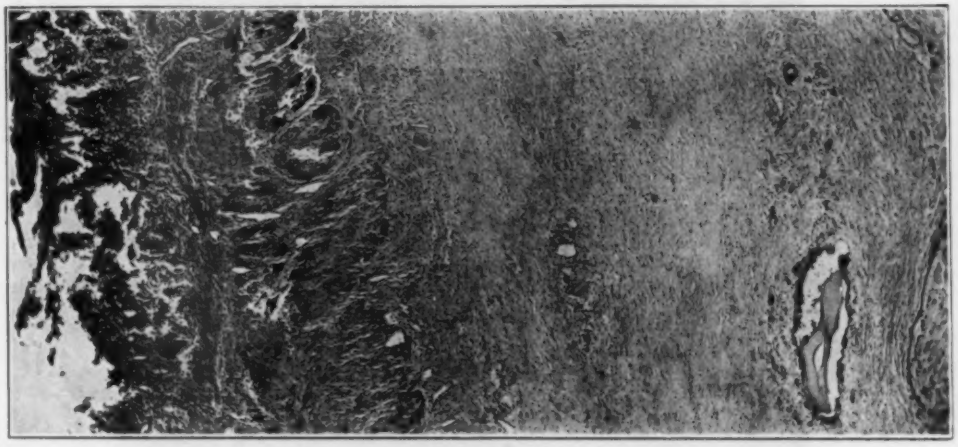

Fig. 1.—Section of gallbladder demonstrating an ulcerated mucous membrane which is otherwise replaced by granulation tissue particularly rich in hemosiderin-laden macrophages. A thickened hypertrophied muscularis is interposed between the mucosa and the markedly thickened fibrosed adventitia. (Courtesy of Dr. Krakower.)

This is a significant finding which will be discussed later, but we will first call on Dr. Krakower to discuss the pathologic features of the gallbladder.

DR. KRAKOWER: We received the gallbladder, which measured 6 by 3 by 3 cm. It was yellow and hemorrhagic, with numerous adhesions under the serosal surface, indicating that it had been adherent to the surrounding structures. The wall of the gallbladder was markedly thickened, measuring 0.5 cm. The mucosa was extensively ulcerated. There were fourteen smaller stones and one large stone. The microscopic slide (fig. 1) reveals much fibrosis of the wall and a diffuse lymphocytic infiltration. The mucosa was ulcerated in numerous areas.

DR. COLE: The postoperative course of this patient was unusual. I think it would be informative to have Dr. Eastman present the details of her convalescence.

DR. EASTMAN: Her immediate postoperative course was uneventful. She was operated on on Aug. 19, 1946, and discharged from the hospital on September 1. She returned at the end of four days, with the complaint that there had been a return of the itching and an increase in the jaundice. Her temperature was 104 F, and she was therefore admitted to the hospital. During the intervening days since operation the T tube had been clamped for two to three hours, and the time had gradually been extended to five and a half hours. In the hospital the T tube was left open for a few days, and symptoms subsided. The patient was discharged. She returned to the clinic over a period of four weeks, after which

FIG. 2.—Choledochogram at the end of the third postoperative week revealed a complete obstruction of the common duct. The distal end of the shadow is narrowed, indicating compression at this point. No stone shadows are visible. The obstruction was presumably caused by a localized pancreatitis; at the time of operation, the head of the pancreas was found to be indurated and slightly enlarged.

time the T tube was gradually clamped off. It was finally removed at the end of the tenth postoperative week.

DR. COLE: This episode illustrates the great value of clamping off the T tube before it is removed. Ordinarily we start clamping the T tube by the middle of the third week, obstructing it for an hour the first day but increasing the time daily until the duct can be obstructed for twenty-four hours without the occurrence of symptoms; after this the tube can be removed. After these precautions, we remove the T tubes placed in the common duct by the end of the fourth week

in at least 75 per cent of cases. In this case a partial obstruction delayed removal of the T tube until the tenth week postoperatively. The explanation for this delay is found in the operative report, which stated that the head of the pancreas was distinctly indurated and slightly enlarged and presumably the seat of mild pancreatitis. Since the common duct usually traverses the head of the pancreas, it can be seen how pancreatitis would produce compression of the duct. When we find a delay in the reestablishment of the flow of bile through the sphincter of Oddi, we always obtain cholangiograms (of the common duct) by injecting iodized oil or "diodrast" into the T tube. This was done on two occasions in this case, namely, at the end of the third week and again at the end of the seventh week

FIG. 3.—Choledochogram at the end of the ninth postoperative week reveals the opaque solution ("diodrast") entering the duodenum, indicating that the obstruction is no longer present. Note filling of the pancreatic duct. The T tube was removed a short time later.

postoperatively. Since Dr. Fuesner, of the x-ray department, is here, we will ask him to discuss the roentenograms.

DR. FUESNER: The first film (taken at the end of the third postoperative week) shows a complete obstruction of the common duct; none of the opaque solution has entered the duodenum. The distal end of the shadow gradually comes to a point, suggesting that the cause of the obstruction is caused by a stenosis (consistent with pancreatitis) and not by a stone. The opaque solution has entered the intrahepaitc bile ducts, but there is only slight dilatation of these ducts. The pancreatic duct is outlined clearly on this roentenogram (fig. 2). The second

roentgenogram, which was taken four weeks after the first, shows opaque material in the intestinal tract, indicating that the obstruction is now relieved (fig. 3).

DR. COLE: Persistence of obstruction in the distal portion of the common duct for a few weeks because of slowly resolving pancreatitis is by no means rare. In our experience pancreatitis is the cause of delay in restoration of patency of the common duct in 5 to 10 per cent of cases in which choledochostomy is performed for the removal of stones. However, such a clear outline of the pancreatic duct is unusual in our experience. Since a couple of our anatomy experts (Dr. Zechel and Dr. Fournier) are here, we shall call on them to express their views as to how often the common and pancreatic ducts join so far proximally.

DR. ZECHEL: In a high percentage of cases we find that these two ducts join several millimeters before the common bile duct enters the intestine.

DR. FOURNIER: I would estimate that in about 50 per cent of cases the common and pancreatic ducts unite several millimeters before the ampulla opens into the intestine.

DR. COLE: It is interesting to speculate on the cause of the pancreatitis in the patient under discussion. In perhaps 75 per cent of cases pancreatitis is associated with disease of the gallbladder and probably actually is secondary to cholecystitis. However, on many occasions there appears to be no relationship of cholecystitis to pancreatitis, as indicated by the fact that we occasionally observe pancreatitis in patients who have had their gallbladders removed. On some occasions the disease appears to be caused by reflux of bile up into the pancreatic duct although obstruction of the pancreatic duct (as by a stone lodged in the terminal end of the common duct) is probably a more common cause of acute edematous pancreatitis. In acute hemorrhagic pancreatitis activation of trypsinogen through some mechanism poorly understood appears to be the important etiologic factor.

DR. ZECHEL: Do you believe that the pancreatitis in this patient was due to the anatomic arrangement of the ducts, perhaps with reflux of bile up into the pancreatic duct?

DR. COLE: I think that that is a possible explanation but one which we can by no means prove. In the common duct of this patient there were numerous small stones, which may have lodged in the end of the duct, thus compressing and obstructing the pancreatic duct.

STUDENT: Is there any relationship between the secretory pressure of the pancreas and liver and the formation of pancreatitis?

DR. COLE: Yes, there might be if an obstruction were present in the end of the duct at the entrance into the duodenum and if the anatomic structure allowed communication between the two ducts. Since the secretory pressure of the liver is slightly greater than that of the pancreas, an obstruction might allow regurgitation of bile into the pancreas, with subsequent production of pancreatitis.

DR. VERMEULEN: Would the presence of the accessory pancreatic duct serve to increase the probability of regurgitation of bile?

DR. COLE: I think it would depend on the presence of collaterals between the duct of Wirsung and the duct of Santorini.

DR. VERMEULEN: It would appear to me that the presence of collaterals between the two pancreatic ducts would tend to increase the probability of pancreatitis if obstruction were present at the sphincter of Oddi, because the collateral pancreatic ducts would decrease the pressure within the ducts and thus allow a greater reflux of bile into the pancreas.

DR. COLE: I think that that appears reasonable.

STUDENT: Do you ever find stones in the common duct without jaundice?

DR. COLE: Yes, frequently. We find stones in the common duct in almost

20 per cent of patients on whom we operate for cholecystitis or cholelithiasis. I would estimate that only about one half of these patients are jaundiced at the time of operation. The presence of stones of various sizes in the common duct of this patient brings up the question of the source of the stones. Do they form in the common duct or do they originate in the gallbladder and pass through the cystic duct into the common duct? I happen to know that Dr. Peterson is interested in this subject. Dr. Peterson, do you have any comments to make on this question?

DR. PETERSON: We are all certain that stones remaining in the common duct will enlarge in size. We have proved this on many occasions when exploration reveals stones measuring up to 2 cm. in diameter. It is obvious that if these stones passed through the cystic duct they did so as small stones and then enlarged in the common duct. There is much debating, however, on the question of whether stones actually can be formed in the common duct. Perhaps on most occasions stones in the common duct arise from the gallbladder, but there is fairly good evidence that stones can arise primarily in the common duct. I think that the case of G. S. proves that stones can be formed in the common duct under certain conditions. The patient, about 50 years of age, had her gallbladder removed prior to her admission to the Research and Educational Hospitals four years ago. She had a carcinoma in the region of the ampulla of Vater, with a tremendously dilated common duct containing white bile and no stones. Dr. Cole performed a pancreatoduodenectomy at that time. Three years later intermittent attacks of jaundice and epigastric pain developed. The first impression was that the jaundice was produced by a metastatic mass compressing the common duct. However, at operation it was found that there was a partial stenosis of the anastomosis formed by choledochojejunostomy and that the common duct was filled with twenty to twenty-five laminated gallstones measuring 1.0 to 1.5 cm. in diameter. At the previous operation (pancreatoduodenectomy) there were no stones in the duct. The facts that stones are rarely present in carcinoma of the ampulla of Vater and that all except the proximal 2 or 3 cm. of the common hepatic duct was removed are circumstantial evidence that the stones formed after the resection, perhaps secondary to stasis produced by a stenosis of the anastomosis between the jejunum and the distal end of the common hepatic duct. It is agreed that two important factors in the formation of gallstones are stasis of bile and the presence of a particle of cholesterol precipitate to act as a nucleus for the stone. In this case the stenosis at the anastomosis between the hepatic duct and the jejunum caused the biliary stasis; this in turn presumably gave rise to precipitation of cholesterol, which later enlarged to form the gallstones found in the stump of the common hepatic duct proximal to the anastomosis.

DR. COLE: I agree that the case which you cited proves that stones can form in the common duct because at the time of the last operation we found a dozen large stones filling the common duct; surely we could not possibly have left so many stones in the duct at the time of the pancreatoduodenectomy three or four years previously.

STUDENT: Does stricture of the common duct ever develop at the site where the T tube is inserted?

DR. COLE: Stricture from that cause is extremely rare. Of about 50 patients with stricture of the common duct whom we have observed during the past eight or ten years, not one has had T tube drainage of the common duct.

STUDENT: Is it ever permissible to suture the common duct after removal of stones without insertion of a T tube?

DR. COLE: Only on rare occasions is suture of the opening in the duct safe. Certainly T tube drainage is indicated for all patients with jaundice. On rare

occasions when jaundice is absent and other symptoms are minimal, suture of the opening in the duct from which stones were removed may be permissible. However in general the risk of closure is too great to justify it, since leakage of bile outside the duct is apt to give rise to an abscess or severe chemical irritation of adjacent structures, perhaps even with formation of a stricture of the common duct.

STUDENT: Is there any rule as to the choice of time for operation for jaundice produced by stone in the common duct?

DR. COLE: To a slight extent, yes. In the first place, operation must be delayed until the diagnosis of obstructive jaundice is fairly certain. It is usually only by a study over a period of at least a few days that we are able to rule out such diagnoses as virus hepatitis or carcinoma of the head of the pancreas. During this period of study, jaundice is commonly increasing in intensity. There is an old tradition that it is bad judgment to operate on a patient with a rising icteric index. I do not believe that undisputed physiologic reasons can be given for this assumption. It is possible that one of the chief advantages in waiting a few days before performing operation is dependent on the fact that after a few days of observation the pressure in the duct and the dilatation may force bile past the obstruction. On other occasions the stone may be dislodged after a few days. At any rate, it is known that obstruction of the common duct over a period of a few days does not produce serious damage to the liver or other organs unless infection develops. You can afford to wait a few days for clarification of diagnosis and also to see if obstruction will be relieved spontaneously. If a complete obstruction is reduced to a partial one, it is much safer to operate (even though jaundice is still present) because bile will be entering the intestinal tract. Complete absence of bile unquestionably does exert some slight damage on body reserve and on other functions. The disadvantage of waiting several days or weeks is that suppurative cholangitis might develop. That is a serious complication and demands immediate correction by operation consisting of drainage of the common duct; at the same time we usually try to remove the obstructive stone. Drainage of the common duct almost invariably relieves the patients promptly.

STUDENT: Will penicillin control the infection in suppurative cholangitis?

DR. COLE: No. We have used penicillin in several cases of suppurative cholangitis, and in not a single instance have we observed a significant drop in temperature or a subsidence of other manifestations. On the other hand, drainage of the common duct always results in rapid improvement in the patient's condition, with subsidence of fever in twenty-four to forty-eight hours. One of the reasons that penicillin is relatively ineffective may lie in the fact that the infection is usually mixed and that Escherichia coli is present. However, I believe that a more important factor is that suppurative cholangitis is in reality an abscess in the common duct and penicillin is notoriously ineffective in eliminating an abscess.

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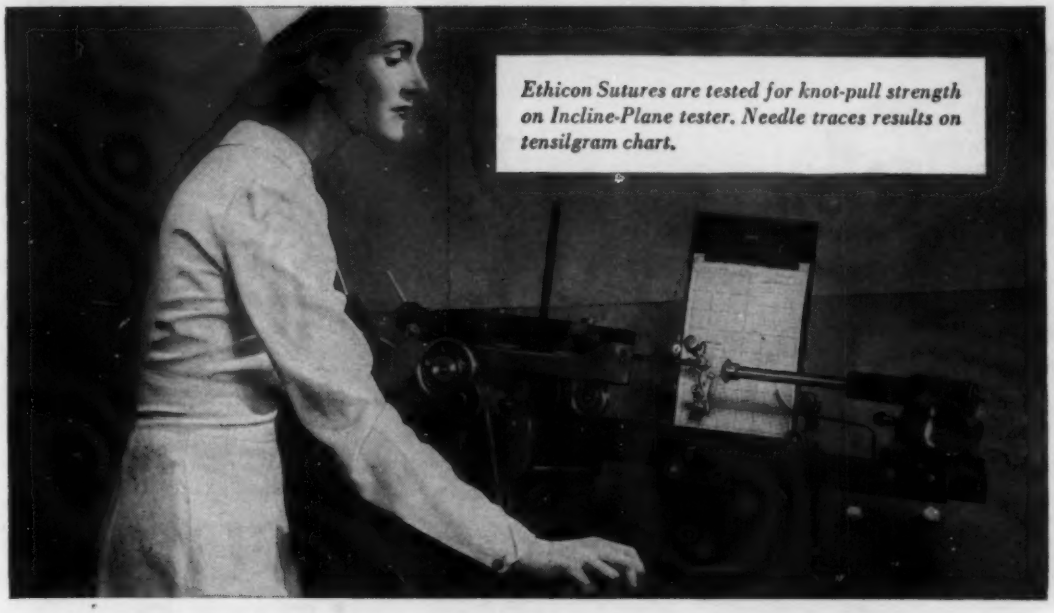

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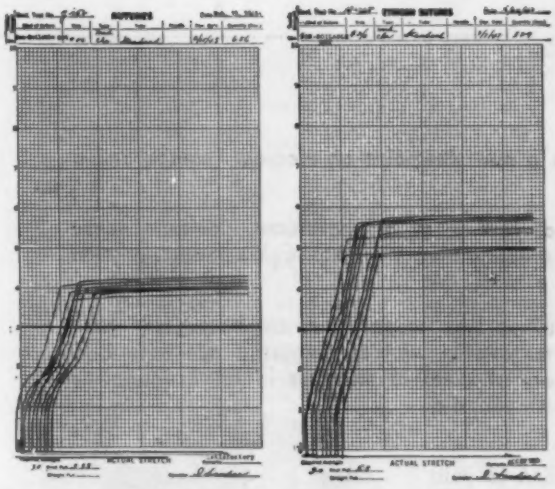

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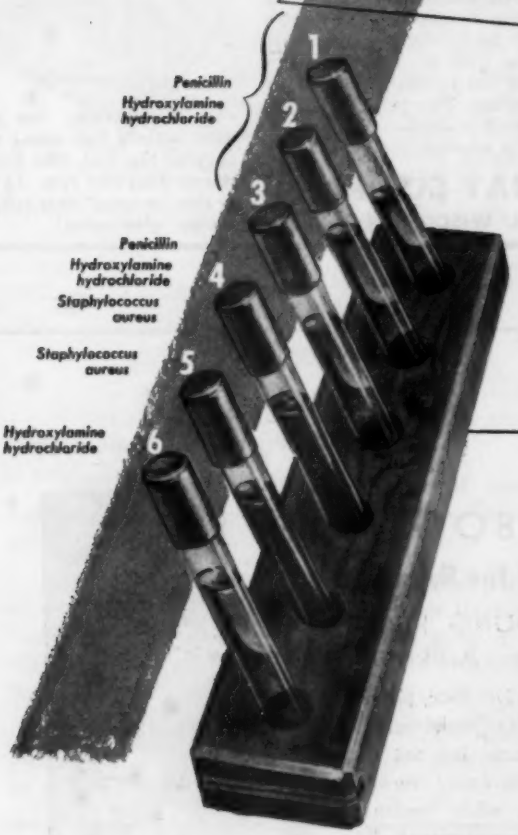


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